



K.S.R.M.

COLLEGE OF ENGINEERING

(UGC - Autonomous)

Accredited by NAAC with A+ Grade & B.Tech. (EEE, ECE, CSE, CE and ME) Programs by NBA

An ISO 9001:2015, 14001: 2015 & 50001: 2018 Certified Institution

ACADEMIC REGULATIONS (R25PG)

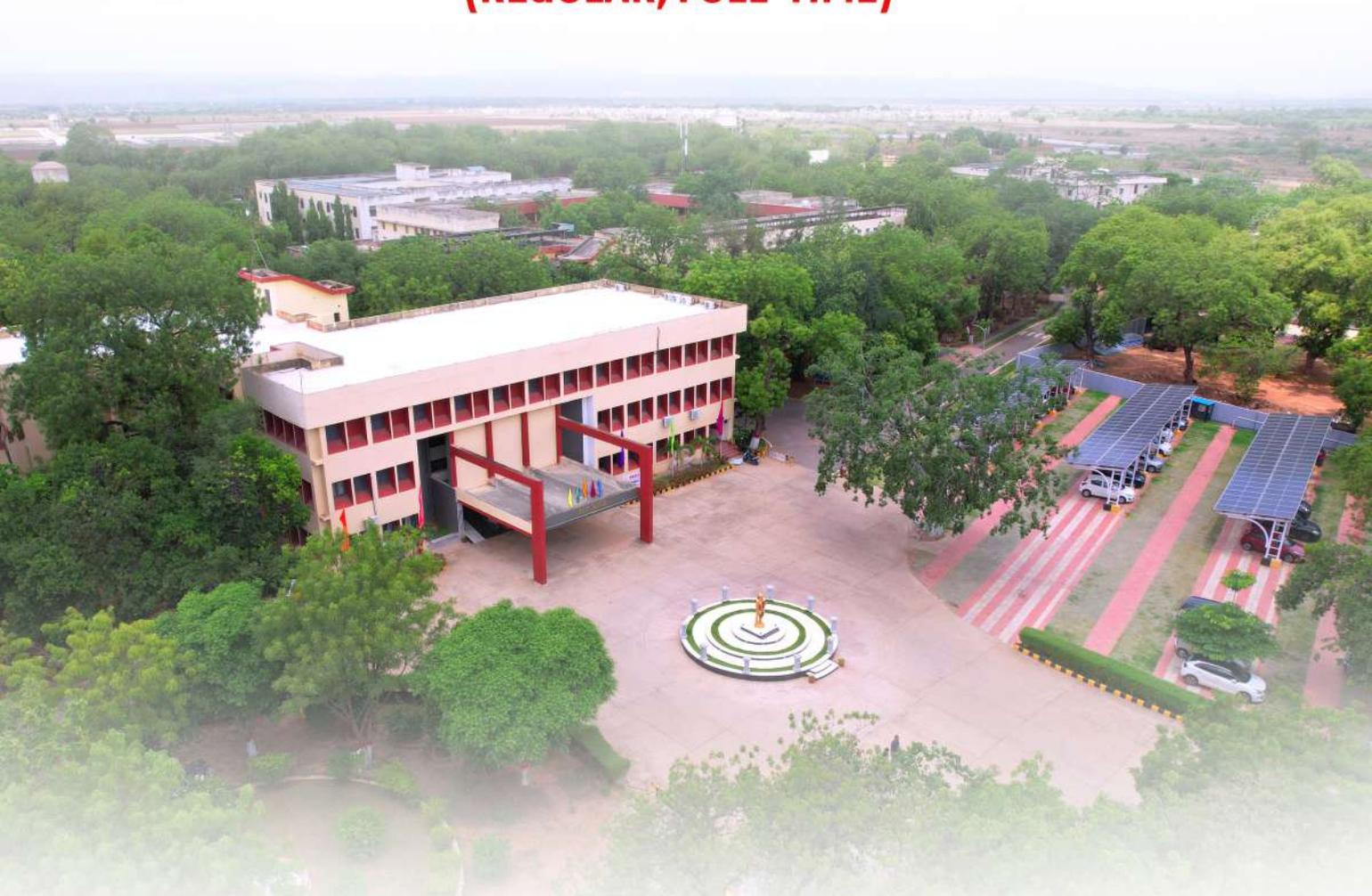
COURSE STRUCTURE AND SYLLABI

(Effective for the students admitted into I year
from the academic year 2025 -2026 onwards)

MASTER OF TECHNOLOGY (M.TECH.)

RENEWABLE ENERGY

(REGULAR, FULL-TIME)



K.S.R.M. COLLEGE OF ENGINEERING

VISION:

To evolve as a centre of repute for providing quality academic programs amalgamated with creative learning and research excellence to produce graduates with leadership qualities, ethical and human values to serve the nation.

MISSION:

- M1.** Provide high quality education with enriched curriculum blended with impactful Teaching-Learning practices.
- M2.** Promote Research, Entrepreneurship and Innovation through industry collaborations.
- M3.** Produce highly competent professional leaders for contributing to socio-economic development of the region and the nation.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION:

To evolve as a department of high repute in Mechanical Engineering and allied fields through effective teaching, learning process and research activities, operating with a sense of professional and social responsibility.

MISSION:

- M1.** To produce Mechanical Engineers with sound knowledge through quality teaching-learning process and well-designed curriculum.
- M2.** To induce critical thinking attitude and inculcate the use of modern tools through interdisciplinary research and develop entrepreneurial skills through industry-institute interaction.
- M3.** To provide opportunities/platforms for students to nurture leadership abilities and ethical values.

M.Tech. RENEWABLE ENERGY

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

- PEO1.** To equip postgraduates with advanced knowledge and analytical skills in renewable energy technologies for designing and optimizing sustainable energy systems.
- PEO2.** To enable graduates to contribute effectively in research organizations, academia, industries, and energy sectors by applying appropriate tools and technologies in renewable energy generation and management.
- PEO3.** To foster innovation, entrepreneurship, and lifelong learning in emerging areas such as solar, wind, bioenergy, hydrogen, and hybrid energy systems.
- PEO4.** To inculcate professional ethics, communication skills, and leadership qualities for effective participation in multidisciplinary teams and for contributing toward sustainable and clean energy development.

PROGRAM OUTCOMES (POs)

After successful completion of the program, graduates will be able to:

- PO1.** Apply advanced concepts of renewable energy engineering to analyze, design, and implement sustainable energy systems.
- PO2.** Conduct research and investigations to address challenges in energy conversion, storage, and integration of renewable energy sources with conventional grids.
- PO3.** Design and develop efficient, reliable, and environment-friendly renewable energy systems and technologies that meet technical and regulatory standards.
- PO4.** Utilize advanced simulation, modelling, and optimization tools for performance analysis, techno-economic evaluation, and management of renewable energy projects.
- PO5.** Communicate effectively with the engineering community and society at large, demonstrating professional ethics and accountability in renewable energy practices.
- PO6.** Engage in lifelong learning to adapt to evolving technologies and understand the societal, environmental, and global impacts of renewable energy solutions.

K.S.R.M. COLLEGE OF ENGINEERING

(AUTONOMOUS)

Academic Regulations of M.Tech. (Full Time/Regular) Programme

(Effective for the students admitted into I year from the Academic Year 2025-26 and onwards)

K.S.R.M. College of Engineering (KSRMCE) offers **Two** Years (**Four** Semesters) full-time Master of Technology (M.Tech.) Degree programme, under Choice Based Credit System (CBCS) in different branches of Engineering and Technology with different specializations.

The affiliating university Jawaharlal Nehru Technological University Anantapur shall confer M.Tech. degree on candidates who are admitted to the programme and fulfill all the requirements for the award of the degree.

1. Award of the M.Tech. Degree

A student will be declared eligible for the award of the M.Tech. degree if he/she fulfils the following:

- 1.1 Pursues a course of study for not less than two academic years and not more than four academic years.
 - 1.2 Registers for 75 credits and secures all 75 credits.
2. Students, who fail to fulfil all the academic requirements for the award of the degree within four academic years from the year of their admission, shall forfeit their seat in M.Tech. course and their admission stands cancelled.

3. Programme of Study:

The following M.Tech. Specializations are offered at present in different branches of Engineering and Technology and are as follows:

Discipline	Name of the Specialization	Code
Civil Engineering	Geo Technical Engineering	12
Electrical and Electronics Engineering	Power Systems	52
Mechanical Engineering	Renewable Energy	99
Computer Science and Engineering	Artificial Intelligence and Data Science	98
Electronics & Communication Engineering	Embedded Systems & VLSI	84

4. Eligibility for Admissions:

- 4.1 Admission to the M. Tech Program shall be made subject to the eligibility, qualification and specialization prescribed by the A.P. State Government/University from time to time.
- 4.2 Admissions shall be made either on the basis of either the merit rank or Percentile obtained by the qualified student in the relevant qualifying GATE Examination/ the merit rank obtained by the qualified student in an entrance test conducted by A.P. State Government (APPGECET) for M.Tech. programmes an entrance test conducted by University/on the basis of any other exams approved by the University, subject to reservations as laid down by the Govt. from time to time.

5. Programme related terms:

5.1 **Credit:** A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (Lecture/Tutorial) or two hours of practical work/field work per week.

Credit definition:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credit

5.2 **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.

5.3 **Choice Based Credit System (CBCS):** The CBCS provides choice for students to select from the prescribed courses.

6. Programme Pattern:

6.1 Total duration of the of M.Tech. programme is two academic years

6.2 Each academic year of study is divided into two semesters.

6.3 Each Semester shall be of 22 weeks duration (inclusive of Examinations), with a minimum of 90 instructional days per semester.

6.4 The student shall not take more than four academic years to fulfill all the academic requirements for the award of M.Tech. degree from the date of commencement of first year first semester, failing which the student shall forfeit the seat in M.Tech. programme.

6.5 The medium of instruction of the programme (including examinations and project reports) will be in English only.

6.6 All subjects/courses offered for the M.Tech. degree programme are broadly classified as follows:

S. No.	Broad Course Classification	Course Category	Description
1.	Core Courses	Foundational & Professional Core Courses (PC)	Includes subjects related to the parent discipline / department / branch of Engineering/specialization.
2.	Elective Courses	Program Elective Courses (PE)	Includes elective courses related to the parent discipline / department / branch of Engineering
		Open Elective Courses (OE)	Elective courses which include inter-disciplinary courses or courses in an area outside the parent discipline which are of importance in the context of special skill development
3.	Mandatory Courses	Quantum Technology and Application	To understand importance of latest technologies, research and process of creation of patents through research
		Research methodology & IPR	
4.	Integrated Experiential Learning Courses	Skill Enhancement courses (SE)	Interdisciplinary / job-oriented / domain courses which are relevant to the industry
		Comprehensive Viva	To test the overall domain knowledge
		Short Term Industry Internship	To provide real time exposure
		Dissertation	To provide application of domain knowledge to solve real problems

S. No.	Broad Course Classification	Course Category	Description
5.	Audit Courses	Mandatory non-credit courses	Covering courses of developing desired attitude among the learners.

- 6.7 The college shall take measures to implement Virtual Labs (<https://www.vlab.co.in>) which provide remote access to labs in various disciplines of Engineering and will help student in learning basic and advanced concept through remote experimentation. Student shall be made to work on virtual lab experiments during the regular labs.
- 6.8 A faculty advisor/mentor shall be assigned to each specialization to advise students on the programme, its Course Structure and Curriculum, Choice of Courses, based on his competence, progress, pre-requisites and interest.
- 6.9 Preferably 25% course work for the theory courses in every semester shall be conducted in the blended mode of learning.

7. Attendance Requirements:

- 7.1 A student shall be eligible to appear for the Semester-End examinations if he/she acquires i) a minimum of 50% attendance in each course and ii) 75% of attendance in aggregate of all the courses.
- 7.2 Condonation of shortage of attendance in aggregate up to 10% (65% and above and below 75%) in each semester may be granted by the College Academic Committee.
- 7.3 Condonation of shortage of attendance shall be granted only on genuine and valid reasons on representation by the candidate with supporting evidence
- 7.4 Students whose shortage of attendance is not condoned in any semester are not eligible to take their semester-end examination of that class.
- 7.5 A stipulated fee shall be payable towards condonation of shortage of attendance.
- 7.6 A student will not be promoted to the next semester unless he satisfies the attendance requirements of the present semester. They may seek re-admission into that semester when offered next.
- 7.7 If any candidate fulfils the attendance requirement in the present semester, he shall not be eligible for readmission into the same class.
- 7.8 If the learning is carried out in blended mode (both offline & online), then the total attendance of the student shall be calculated considering the offline and online attendance of the student.

8. Evaluation – Distribution and Weightage of Marks:

The performance of a student in each semester shall be evaluated course - wise (irrespective of credits assigned), for a maximum of 100 marks for theory and 100 marks for practical, based on Internal Evaluation and Semester-End Examination.

- 8.1 There shall be five units in each of the theory courses. For the theory courses 60 marks will be for the Semester-End Examination and 40 marks will be for Internal Evaluation.
- 8.2 Two Internal Examinations shall be conducted for 30 marks each, one in the middle of the Semester and the other immediately after the completion of instruction period. The other 10 marks is awarded for continuous assessment in the form of assignments, quizzes, open book examination, presentation, etc. First mid examination shall be conducted for I & II units of the syllabus and second mid examination for III, IV & V units. Each mid

exam shall be conducted for a total duration of 120 minutes with 3 questions (without choice) and each question carries 10 marks. Final Internal marks for a total of 40 marks shall be arrived at by considering the marks secured by the student in both the internal examinations with 80% weightage to the better internal exam and 20% to the other.

- 8.3 The following pattern shall be followed in the End Examination:
- i. Five questions shall be set from each of the five units with either/or type for 12 marks each.
 - ii. All the questions have to be answered compulsorily.
 - iii. Each question may consist of one, two or more sub-questions.
- 8.4 For practical courses, 60 marks shall be for the Semester-End Examinations and 40 marks will be for internal evaluation based on the day-to-day performance.
- The internal evaluation based on the day-to-day work-10 marks, record- 10 marks and the remaining 20 marks to be awarded by conducting an internal laboratory test. The semester-end examination shall be conducted by the examiners, with a breakup mark of Procedure-10, Experimentation-25, Results-10, Viva-Voce-15.
- 8.5 There shall be Mandatory **Audit courses** in I & II semesters for zero credits. There is no external examination for audit courses. However, attendance shall be considered while calculating aggregate attendance and student shall be declared to have passed the mandatory course only when he/she secures 50% or more in the internal examinations. In case, the student fails, a re-examination shall be conducted for failed candidates for 40 marks for every six months/semester satisfying the conditions mentioned in item 1 & 2 of the regulations.
- 8.6 A candidate shall be deemed to have secured the minimum academic requirement in a course if he secures a minimum of 40% of marks in the Semester-End Examination and a minimum aggregate of 50% of the total marks in the Semester-End Examination and Internal Evaluation taken together.
- 8.7 In case the candidate does not secure the minimum academic requirement in any of the courses he/she has to reappear for the Semester-End Examination either supplementary or regular in that course or repeat the course when next offered or do any other specified course as may be required.
- 8.8 The laboratory records and mid semester test papers shall be preserved for a minimum of 3 years in the respective institutions as per the University norms and shall be produced to the Committees of the University as and when the same are asked for.

9. Credit Transfer Policy

As per University Grants Commission (Credit Framework for Online Learning Courses through SWAYAM) Regulation, 2016, students are allowed to do up to a maximum of 40% of the Professional and Open Electives in a semester through SWAYAM/SWAYAM Plus.

- 9.1 The college offers credit mobility for MOOCs and give the equivalent credit weightage to the students for the credits earned through online learning courses through SWAYAM platform.
- 9.2 The online learning courses available on the SWAYAM platform will be considered for credit transfer. SWAYAM course credits are as specified in the platform
- 9.3 Student registration for the MOOCs shall be only through the college, it is mandatory for the student to share necessary information with the college
- 9.4 The institution will list out the courses to be permitted for credit transfer through

SWAYAM. However, while selecting courses in the online platform institution would essentially avoid the courses offered through the curriculum in the offline mode.

- 9.5 The institution will notify at the beginning of semester the list of the online learning courses eligible for credit transfer in the forthcoming Semester.
- 9.6 Students may register for an 8-week (2 credits) or 12-week (3 credits) SWAYAM / SWAYAM plus course with the approval of the Head of the Department (HoD).
- 9.7 Examination fees, if applicable, shall be borne by the student. Pass marks and grading will be as per the JNTUA academic regulations.
- 9.8 A student must get minimum 40% marks for assignments and quizzes on the SWAYAM/ SWAYAM plus platform to be eligible for the semester-end examination. The students who are unable to get minimum internal marks in SWAYAM/ SWAYAM plus platform, they have to re-register for the course in subsequent semester through SWAYAM/ SWAYAM plus platform.
- 9.9 The semester-end exam may be conducted by the National Testing Agency (NTA), the National Programme on Technology Enhanced Learning (NPTEL) or the College during the regular term-end exams. Evaluation shall comprise 60% weightage for the semester-end examination and 40% for assignments and quizzes conducted by the SWAYAM/ SWAYAM plus course coordinator. The student has to get 50% marks for internal and external with minimum of 40% marks in the external examination to declare them as pass.
- 9.10 The institution also ensures that the student completes the course and produces the course completion certificate as per the academic schedule given for the regular courses in that semester. However, the credits will be transferred to the students who got minimum 50% marks with 40% marks in the external examination
- 9.11 The institution will designate a faculty member as a Mentor for each course to guide the students from registration till completion of the credit course.
- 9.12 The college will ensure no overlap of SWAYAM MOOC exams with that of the semester-end examination schedule. In case of delay in SWAYAM results, the college will re-issue the marks sheet for such students.
- 9.13 Student pursuing courses under MOOCs shall acquire the required credits only after successful completion of the course and submitting a certificate issued by the competent authority along with the minimum 50% of marks and grades.
- 9.14 The institution maintains the following in the examination section and submits as and when demanded by the university:
 - a) List of students who have passed MOOC courses in the current semester along with the certificates of completion.
 - b) Undertaking form filled by the students for credit transfer.
- 9.15 The college will resolve any issues that may arise in the implementation of this policy from time to time and shall review its credit transfer policy in the light of periodic changes brought by UGC, SWAYAM, NPTEL and state government.

Note: Students are also be permitted to register for MOOCs offered through online platforms other than SWAYAM NPTEL. In such cases, credit transfer shall be permitted only after seeking approval of the Principal with the recommendations of the concerned HoD and Dean, Academics at least three months prior to the commencement of the semester.

10. Re-registration for Improvement of Internal Evaluation Marks:

A candidate shall be given one chance to re-register for each course provided the internal marks secured by a candidate are less than 50% and has failed in the end examination

- 10.1 The candidate should have completed the course work and obtained examinations results for **I, II and III** semesters.
- 10.2 The candidate should have passed all the courses for which the Internal Evaluation marks secured are more than 50%.
- 10.3 Out of the courses the candidate has failed in the examination due to Internal Evaluation marks secured being less than 50%, the candidate shall be given one chance for each Theory course and for a maximum of **three** Theory courses for Improvement of Internal evaluation marks.
- 10.4 The candidate has to re-register for the chosen courses and fulfill the academic requirements.
- 10.5 For re-registration, the candidates have to apply to the Principal through the respective HoD by paying the requisite fees and get approval from the Principal before the start of the semester in which re-registration is required
- 10.6 In the event of availing the Improvement of Internal evaluation marks, the internal evaluation marks as well as the Semester-End Examinations marks secured in the previous attempt(s) for the reregistered courses stand cancelled.

11. Evaluation of Project/Dissertation Work:

The Project work shall be initiated at the beginning of the III-Semester and the duration of the Project is of two semesters. Evaluation of Project work is for 300 marks with 200 marks for internal evaluation and 100 marks for external evaluation. Progress of the project work is monitored through three reviews:

- Project review – I at the beginning of the III semester for zero marks
- Project review – II at the end of the third semester for 100 marks
- Project review – III before submission of the thesis i.e., end of the IV semesters for 100 marks

External evaluation of final Project work viva voce in IV semester shall be for 100 marks.

A Project Review Committee (PRC) shall be constituted with the Head of the Department as Chairperson, Project Supervisor and one faculty member of the department offering the M.Tech. programme.

- 11.1 A candidate is permitted to register for the Project Work in III Semester after satisfying the attendance requirements in all the courses, both theory and laboratory (in I & II semesters).
- 11.2 A candidate is permitted to submit Project dissertation with the approval of PRC. The candidate has to pass all the theory, practical and other courses before submission of the Thesis.
- 11.3 Project work shall be carried out under the supervision of teacher in the parent department concerned.
- 11.4 A candidate shall be permitted to work on the project in an industry/research organization on the recommendation of the Head of the Department. In such cases, one

- of the teachers from the department concerned would be the internal guide and an expert from the industry/research organization concerned shall act as co-supervisor/external guide. It is mandatory for the candidate to make full disclosure of all data/results on which they wish to base their dissertation. They cannot claim confidentiality simply because it would come into conflict with the Industry's or R&D laboratory's own interests. A certificate from the external supervisor is to be included in the dissertation.
- 11.5 Continuous assessment of Project Work - I and Project Work – II in III & IV semesters respectively will be monitored by the PRC.
 - 11.6 The candidate shall submit status report by giving seminars in three different phases (two in III semester and one in IV semester) during the project work period. These seminar reports must be approved by the PRC before submission of the Project Thesis.
 - 11.7 After registration, a candidate must present in Project Review - I, in consultation with his Project Supervisor, the title, objective and plan of action of his Project work to the PRC for approval within four weeks from the commencement of III Semester. Student shall initiate the project work, only after obtaining the approval of the PRC.
 - 11.8 The Project Review - II in III semester carries internal marks of 100. Evaluation should be done by the PRC for 50 marks and the Supervisor will evaluate the work for the other 50 marks. The Supervisor and PRC will examine the Problem Definition, Objectives, Scope of Work, Literature Survey in the same domain and progress of the Project Work.
 - 11.9 A candidate has to secure a minimum of 50% of marks to be declared successful in Project Review - II. Only after successful completion of Project Review – II, candidate shall be permitted for Project Work Review – III in IV Semester. The unsuccessful students in Project Review - II shall reappear after three months.
 - 11.10 The Project Review - III in IV semester carries 100 internal marks. Evaluation should be done by the PRC for 50 marks and the Supervisor will evaluate it for the other 50 marks. The PRC will examine the overall progress of the Project Work and decide whether or not eligible for final submission. A candidate has to secure a minimum of 50% of marks to be declared successful in Project Review - III. If student fails to obtain the required minimum marks, he/she has to reappear for Project Review - III after a month.
 - 11.11 For the approval of PRC, the candidate shall submit the draft copy of dissertation to the Head of the Department and make an oral presentation before the PRC.
 - 11.12 After approval from the PRC, the student is permitted to submit a report. The dissertation report will be accepted only when the plagiarism is within 30% checked through Turnitin software (repository mode). The plagiarism report shall be submitted along with the dissertation report.
 - 11.13 Research paper related to the Project Work shall be published in an SCI / SCIE / ESCI / Scopus or in conference proceedings with ISBN number organized by professional societies such as IEEE, IET, etc.
 - 11.14 After successful plagiarism check and publication of research paper, three copies of the dissertation certified by the supervisor and HOD shall be submitted to the College.
 - 11.15 The dissertation shall be adjudicated by an external examiner selected by the College. For this, a panel of three examiners shall be submitted by the supervisor concerned and department head for each student. However, the dissertation will be adjudicated by one examiner nominated by the Principal.

- 11.16 If the report of the examiner is not satisfactory, the candidate shall revise and resubmit the dissertation, in the time frame as decided by the PRC. If report of the examiner is unfavorable again, the thesis shall be summarily rejected. The candidate has to reregister for the project and complete the project within the stipulated time after taking the approval from the Principal.
- 11.17 If the report of the examiner is satisfactory, the Head of the Department shall coordinate and make arrangements for the conduct of Project Viva voce exam.
- 11.18 The Project Viva voce examinations shall be conducted by a board consisting of the Supervisor, Head of the Department and the external examiner who has adjudicated the dissertation. For Dissertation Evaluation (Viva voce) in IV Sem. there are external marks of 100 and it is evaluated by external examiner. The candidate has to secure a minimum of 50% marks in Viva voce exam.
- 11.19 If he fails to fulfill the requirements as specified, he will reappear for the Project Viva voce examination only after three months. In the reappeared examination also, if he fails to fulfill the requirements, he will not be eligible for the award of the degree.

12 Industry Internships:

Industry internship either onsite or virtual with a minimum of 06-08 weeks duration, done at the end of 1st year second semester. It shall be completed in collaboration with local industries, Govt. Organizations, construction agencies, Power projects, software MNCs or any industries in the areas of concerned specialization of the PG program. The student shall register for the internship as per course structure after commencement of academic year.

Evaluation of the summer internships shall be through the departmental committee. A student will be required to submit a summer internship report to the concerned department and appear for an oral presentation before the departmental committee comprising of Head of the Department, Mentor/Supervisor of the internship and a senior faculty member of the department. A certificate of successful completion from industry shall be included in the report. Internship will be evaluated for 100 marks with 50 marks for the report evaluated by the mentor and 50 marks for oral presentation. A student should secure minimum 50% of marks for successful completion. In case, if a student fails, he/she shall reappear as and when semester supplementary examinations are conducted by the College.

13 Comprehensive Viva

A Comprehensive Viva shall be conducted after the II Semester examinations for 100 marks by a committee consisting of the Head of the Department, one senior faculty member of the same specialization, and an external subject expert appointed by the Principal. The student must secure a minimum of 50% marks to be declared as passed

14 Credits for Co-curricular Activities

A Student should earn 01 credits under the head of co-curricular activities, viz., attending Conference, Scientific Presentations and Other Scholarly Activities. The guidelines for awarding Credits for Co-curricular Activities are detailed in the following Table.

Name of the Activity	Maximum Credits / Activity
Participation in National Level Seminar / Conference / Workshop / Training programs (related to the specialization of the student)	0.5
Participation in International Level Seminar / Conference / Workshop / Training programs held outside India (related to the specialization of the student)	1
Academic Award/Research Award from State Level / National Agencies	0.5
Academic Award / Research Award from International Agencies	1
Research / Review Publication in National Journals (Indexed in Scopus / Web of Science)	0.5
Research / Review Publication in International Journals with Editorial board outside India (Indexed in Scopus / Web of Science)	1

Note:

- i) Credit shall be awarded only for the first author. Certificate of attendance and participation in a Conference/Seminar is to be submitted for awarding credit. A minimum participation of five days is required to earn the necessary credits. Alternatively, the student may attend five different one day programs to meet this requirement.
- ii) Certificate of attendance and participation in workshops and training programs (Internal or External) is to be submitted for awarding credit. The total duration should be at least one week.
- iii) Participation in any activity shall be permitted only once for acquiring required credits under cocurricular activities

15 Grading:

As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades and corresponding percentage of marks shall be followed:

After each course is evaluated for 100 marks, the marks obtained in each course will be converted to a corresponding letter grade as given below, depending on the range in which the marks obtained by the student fall.

Structure of Grading of Academic Performance

Range in which the marks in the course fall	Grade	Grade points Assigned
≥ 90	S (Superior)	10
≥ 80 < 90	A (Excellent)	9
≥ 70 < 80	B (Very Good)	8
≥ 60 < 70	C (Good)	7
≥ 50 < 60	D (Pass)	6
< 50	F (Fail)	0
Absent	Ab (Absent)	0

- i) A student obtaining Grade "F" or Grade "Ab" in a course shall be considered failed and will be required to reappear for that course when it is offered the next supplementary examination.
- ii) For noncredit audit courses, "Satisfactory" or "Unsatisfactory" shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA / CGPA / Percentage.

Computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The Semester Grade Point Average (SGPA) is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.,

$$SGPA = \frac{\sum (C_i \times G_i)}{\sum C_i}$$

where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

- i) The Cumulative Grade Point Average (CGPA) will be computed in the same manner considering all the courses undergone by a student over all the semesters of a program, i.e.,

$$CGPA = \frac{\sum (C_j \times S_i)}{\sum C_j}$$

where " S_i " is the SGPA of the i^{th} semester and C_j is the total number of credits up to that semester.

- ii) Both SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.
- iii) While computing the SGPA the courses in which the student is awarded Zero grade points will also be included.

Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters S, A, B, C, D and F.

16 Award of Class:

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of M. Tech. Degree, he shall be placed in one of the following three classes:

Class Awarded	CGPA to be secured
First Class with Distinction	≥ 7.5
First Class	$6.5 \leq < 7.5$
Pass Class	< 6.5

17 Exit Policy:

The student shall be permitted to exit with a PG Diploma based on his/her request to the university through the respective institution at the end of first year subject to passing all the courses in first year.

The Academic Council shall resolve any issues that may arise in the implementation of this policy from time to time and shall review the policy in the light of periodic changes brought by UGC, AICTE and State government.

18 Withholding of Results:

If the candidate has any case of in-discipline pending against him/her, the result of the candidate shall be withheld, and he/she will not be allowed/promoted into the next higher semester. The issue of degree is liable to be withheld in such cases.

19 Transitory Regulations

Discontinued, detained, or failed candidates are eligible for readmission as and when the semester is offered after fulfilment of academic regulations. Candidates who have been detained for want of attendance or not fulfilled academic requirements or who have failed after having undergone the course in earlier regulations or have discontinued and wish to continue the course are eligible for admission into the unfinished semester from the date of commencement of class work with the same or equivalent courses as and when courses are offered, subject to Section 2 and they will follow the academic regulations into which they are readmitted.

20 General:

- 20.1 The academic regulations should be read as a whole for purpose of any interpretation.
- 20.2 Disciplinary action for Malpractice / improper conduct in examinations is appended.
- 20.3 There shall be no places transfer within the constituent colleges and affiliated colleges of Jawaharlal Nehru Technological University Anantapur.
- 20.4 Where the words “he”, “him”, “his”, occur in the regulations, they include “she”, “her”, “hers”.
- 20.5 In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
- 20.6 The College may change or amend the academic regulations or syllabi at any time and the changes or amendments shall be made applicable to all the students on rolls with effect from the dates notified by the College.

**RULES FOR
DISCIPLINARY ACTION FOR MALPRACTICES / IMPROPER CONDUCT IN
EXAMINATIONS**

S.No.	Nature of Malpractices / Improper conduct	Punishment
	<i>If the candidate:</i>	
1.(a)	Possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the course of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the course of the examination).	Expulsion from the examination hall and cancellation of the performance in that course only.
1.(b)	Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through cell phones with any candidate or persons in or outside the exam hall in respect of any matter.	Expulsion from the examination hall and cancellation of the performance in that course only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him.
2	Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the course of the examination (theory or practical) in which the candidate is appearing.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the courses of that semester/year. The Hall Ticket of the candidate is to be cancelled and sent to the University.
3	Impersonates any other candidate in connection with the examination.	The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred for four consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. The performance of the original candidate who has been impersonated, shall be cancelled in all the courses of the examination (including practicals and project work) already appeared and shall not be allowed to appear for examinations of the remaining courses of that semester/year. The candidate is also debarred for four consecutive semesters from class work and all University examinations if his

S.No.	Nature of Malpractices / Improper conduct	Punishment
	<i>If the candidate:</i>	
		involvement is established. Otherwise, the candidate is debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, he will be handed over to the police and a case is registered against him.
4.	Smuggles in the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination.	Expulsion from the examination hall and cancellation of performance in that course and all the other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat.
5.	Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks.	Cancellation of the performance in that course only.
6.	Refuses to obey the orders of the Chief Superintendent /Assistant - Superintendent /any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the officer-in charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the officer-in-charge, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct	In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that course and all other courses the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the courses of that semester / year. If the candidate physically assaults the invigilator / officer-in-charge of the Examinations, then the candidate is also debarred and forfeits his/her seat. In case of outsiders, they will be handed over to the police and a police case is registered against them.

S.No.	Nature of Malpractices / Improper conduct	Punishment
	<i>If the candidate:</i>	
	of the examination.	
7	Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall.	Expulsion from the examination hall and cancellation of performance in that course and all the other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat.
8	Possess any lethal weapon or firearm in the examination hall.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred and forfeits the seat.
9.	If student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8.	Student of the colleges expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester / year. The candidate is also debarred and forfeits the seat. Person (s) who do not belong to the College will be handed over to police and, a police case will be registered against them.
10.	Comes in a drunken condition to the examination hall.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester / year.
11.	Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny.	Cancellation of the performance in that course only or in that course and all other courses the candidate has appeared including practical examinations and project work of that semester / year

S.No.	Nature of Malpractices / Improper conduct	Punishment
	<i>If the candidate:</i>	
		examinations, depending on the recommendation of the committee.
12.	If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the University for further action to award suitable punishment.	

1. Malpractices identified by squad or special invigilators
2. Punishments to the candidates as per the above guidelines.
3. Punishment for institutions: (if the squad reports that the college is also involved in encouraging malpractices)
4. A show cause notice shall be issued to the college.
5. Impose a suitable fine on the college.
6. Shifting the examination center from the college to another college for a specific period of not less than one year.

Note:

Whenever the performance of a student is cancelled in any course/courses due to Malpractice, he has to register for End Examinations in that course/courses consequently and has to fulfil all the norms required for the award of Degree.

COURSE STRUCTURE
M.Tech.
RENEWABLE ENERGY
I-SEMESTER

S. No.	Course Code	Course Title	Category	Hours per week			Credits
				L	T	P	
1.	2599101	Energy Audit and Management	PC	3	0	0	3
2.	2599102	Introduction to Renewable Energy Systems	PC	3	0	0	3
3.	Program Elective-I		PE	3	0	0	3
	2599103	Hydrogen and Fuel Cell Technologies					
	2599104	Solar Energy Technology					
	2599105	Process Modeling and Simulation in Renewable Energy Systems					
4.	Program Elective-II		PE	3	0	0	3
	2599106	Energy Storage Technology					
	2599107	Energy Conservation by Waste heat recovery					
	2599108	Developing Energy Efficiency and Renewable energy Projects					
5.	2599151	Fuels Lab	PC	0	0	4	2
6.	2599152	Solar Energy Engineering Lab	PC	0	0	4	2
7.	2599153	Bioenergy Lab	SE	0	1	2	2
8.	2599171	Research Methodology and Intellectual Property Rights	MC	2	0	0	2
9.	Audit Course-I		AC	2	0	0	0
	2599181	English for Research Paper Writing					
	2512181	Disaster Management					
	2598181	Essence of Indian Traditional Knowledge					
TOTAL				16	1	10	20

II-SEMESTER

S. No.	Course Code	Course Title	Category	Hours per week			Credits
				L	T	P	
1.	2599201	Wind Energy Technology	PC	3	0	0	3
2.	2599202	Computational Fluid Dynamics	PC	3	0	0	3
3.	Program Elective-III		PE	3	0	0	3
	2599203	Solar Refrigeration and Air Conditioning					
	2599204	Energy Recovery and Management Systems					
	2599205	Energy Efficiency and Renewable Energy Systems					
4.	Program Elective-IV		PE	3	0	0	3
	2599206	Hydrogen Production, Storage and Fuel Cell Applications					
	2599207	Bio Energy					
	2599208	Renewable Energy Process Modelling and Analysis					
5.	2599251	Wind Energy Lab	PC	0	0	4	2
6.	2599252	Control systems and simulation Lab	PC	0	0	4	2
7.	2599253	Comprehensive Viva Voce	PC	0	0	0	2
8.	2598281	Quantum Technologies and Applications	MC	2	0	0	2
9.	Audit Course-II		AC	2	0	0	0
	25HS201	Pedagogy Studies					
	25HS202	Personality Development through Life Enlightenment Skills					
	25HS203	Yoga for Stress Management					
TOTAL				16	0	8	20

* Students have to undergo an Industry Internship during Summer break in II-Semester for 06 to 08 weeks duration.

III-SEMESTER

S. No.	Course Code	Course Title	Category	Hours per week			Credits
				L	T	P	
1.	Program Elective-V		PE	3	0	0	3
	2599301	Economics and Financing of Renewable Energy Systems					
	2599302	Environmental Engineering and Pollution Control					
	2599303	Fuels and Combustion Technology					
2.	2599351	Dissertation Phase-I	PR	0	0	20	10
3.	2599352	Industry Internship	PC	0	0	0	2
4.	2599353	Co-Curricular Activities	MC	0	0	0	1
5.		Open Elective	OE	3	0	0	3
TOTAL				6	0	20	19

OPEN ELECTIVE

S.No.	Course Code	Course Name	Offered by Dept.
1	2512381	Green Buildings	Civil
2	2512382	Road Safety Engineering	
3	2598381	Advanced Data Structures & Algorithms	CSE
4	2598382	Cloud Computing	
5	2598383	AI Tools	
6	2584381	IoT and its Applications	ECE
7	2552381	Photovoltaic Systems	EEE
8	2599381	Integrated Product Design and Development	ME
9	25HS381	Advanced Numerical Methods and Computational Mathematics	Mathematics
10	25HS382	Mathematics for Machine Learning and Data Science	
11	25HS383	Statistical Learning Theory and Mathematical Foundations of AI	
12	25HS384	Chemistry of Nanomaterials and Applications in Engineering	Chemistry
13	25HS385	Photonics For Engineers	Physics

IV-SEMESTER

S. No.	Course Code	Course Title	Category	Hours per week			Credits
				L	T	P	
1.	2599451	Dissertation Phase-II	PR	0	0	32	16
TOTAL				0	0	32	16

2599101	M.Tech., I-SEMESTER ENERGY AUDIT AND MANAGEMENT (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Identify and describe various energy resources, their utilization patterns, and their impact on the environment.
- CO2.** Apply the concepts of energy and heat balance to identify and analyze energy conservation opportunities in industrial and building systems.
- CO3.** Conduct energy audits using appropriate instruments and evaluate energy performance for effective energy management.
- CO4.** Formulate energy policies and develop action plans with suitable financial analysis and implementation strategies.
- CO5.** Apply project management principles and monitoring techniques for efficient and sustainable energy utilization.

SYLLABUS:

UNIT- I: ENERGY SCENARIO (10 Periods)

Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features, Kyoto Protocol, Global warming.

UNIT- II: ENERGY CONSERVATION (10 Periods)

Introduction, Energy and heat balances, Methods for preparing process flow chart, material and energy balance in different processes, Sankey diagram, Energy conservation in boilers, Energy conservation in steam systems, Heat exchanger networking, concept of pinch, lighting systems energy efficiency study, Energy conservation opportunities; conservation in buildings, opportunities in compressed air systems, Refrigeration plants etc.

Principles and Objectives of Energy Management: Introduction, Energy Planning, Energy Staffing, Energy Organization, Energy Requirement, Energy Costing, Energy Budgeting, Energy Monitoring, Energy Consciousness Energy Conversions, Energy Efficient Equipment, Energy Management Professionals, Environment Pollution due to Energy Use, Evaluation of alternative Energy Sources.

UNIT- III: ENERGY MANAGEMENT & AUDIT (08 Periods)

Definition, Types of energy audit, Energy management (audit) approach-understanding energy costs, Ventilation Audit, Measuring and Detection Instruments for Energy Survey, Scope of Energy audit, Bench marking, Energy performance, Matching energy use to requirement, maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

UNIT- IV: ENERGY ACTION PLANNING (09 Periods)

Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Design of Energy Management Programmes, Saving Energy and Implementation of Energy Conservation, location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability. Motivating- motivation of employees: Information system designing barriers, Strategies; Marketing and communicating-

training and planning.

Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques, Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

UNIT- V: PROJECT MANAGEMENT

(08 Periods)

Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification.

Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques, energy consumption, Production, Cumulative sum of differences (CUSUM).

Total Periods: 45

Textbooks:

- T1. Guide to Energy Management, Capehart, B. L., Turner, W. C., & Kennedy, W. J. The Fairmont Press, Inc. Atlanta, 2019
- T2. Handbook of Energy Engineering, Thumann, A., & Mehta, D. P., CRC Press, 2001
- T3. Energy Conservation in the Process Industries, Kenney W. F., Academic Press, 2012.

Reference Books:

- R1. Energy Management Handbook (Vol. 2). Turner, W. C., & Doty, S. Lulu Press, 2013
- R2. Energy Management and Conservation Hand Book. Kreith, F. & Goswami, D. Y. CRC Press, 2007.
- R3. Environment Management and Audit. Rao, P. S., & Rao, P. R. Deep Publications, 2000

Web Resources:

1. https://nptel.ac.in/courses/108106022?utm_source=chatgpt.com
2. https://onlinecourses.swayam2.ac.in/nou23_es05/preview?utm_source=chatgpt.com
3. https://onlinecourses.nptel.ac.in/noc23_hs69/preview?utm_source=chatgpt.com

2599102	M.Tech., I-SEMESTER INTRODUCTION TO RENEWABLE ENERGY SYSTEMS (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the need and fundamentals of various renewable energy sources and solar radiation concepts.
- CO2.** Analyse solar thermal, photovoltaic, and wind energy systems and their performance.
- CO3.** Evaluate biomass conversion and geothermal energy technologies for sustainable power generation.
- CO4.** Describe and compare hydro and ocean energy systems and their applications.
- CO5.** Apply the principles of fuel cells and hydrogen energy systems for clean energy solutions.

SYLLABUS:

UNIT-I: NEED OF SOURCES OF RENEWABLE ENERGY: (09 Periods)

Introduction to different sources of renewable energy, e.g., Solar Energy, Wind Energy, Bio-mass, Geothermal Energy, Ocean energy, Solar Energy and Applications.

Basic concepts of Radiations: Solar radiation, Direct and Indirect radiation, Radiation measuring instrument, applications etc.

UNIT-II: SOLAR AND WIND ENERGY (09 Periods)

Basics of solar thermal applications both low and high temperature ranges such as water heating, air heating, steam generation, desalination of water, crop drying and power generation, Principle of photovoltaic including introduction to various components of a photovoltaic systems for standalone/hybrid/grid connected systems

WIND ENERGY: Wind Resource assessment including instrumentation used in resource assessment, basic theory of wind, wind power generators both for decentralized applications and grid connected systems, performance characteristics, Augmentation of wind power, Betz criteria.

UNIT-III: BIO AND GEOTHERMAL ENERGY (09 Periods)

BIOENERGY: Types and availability of biomass resources, various methods of biomass utilization for energy generation: gasification, briquette, palatization, syngas, Anaerobic/Aerobic digestion, ethanol and biodiesel production, types of Bio-gas digesters, Combustion characteristics of bio- gas and its different utilizations.

GEOTHERMAL ENERGY: availability and methods of utilization of geothermal resource for thermal applications and electricity generation

UNIT-IV: HYDRO AND OCEAN ENERGY (09 Periods)

HYDRO ENERGY: Basic principle of hydroelectric power generation, classification of hydropower projects (pico, micro, mini, small hydro sand large hydro projects), types of hydro turbine, various components of hydropower projects.

OCEAN ENERGY: Principles utilization, thermodynamic cycles, tidal and wave energy, potential and conversion technique, Principle of ocean thermal energy conversion system.

UNIT-V: FUEL CELLS AND HYDROGEN ENERGY (09 Periods)

Introduction, principle of fuel cells, thermodynamic analysis of fuel cells, types of fuel cells, fuel cell batteries, applications of fuel cells. Hydrogen as a renewable energy source, sources of hydrogen, fuel for vehicles, hydrogen production- direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production.

Total Periods: 45

Textbooks:

- T1.** Solar Engineering of Thermal Processes, Duffie, J. A., & Beckman, W. Wiley Eastern Publications. 2013, Fourth Edition.
- T2.** Fundamentals of Renewable Energy Sources, Tiwari, G. N., & Ghosal, M. K., Alpha Science International Limited, 2007.
- T3.** Fundamentals of Renewable Energy Systems, Mukherjee, D., & Chakrabarti, S. New Age International, 2014.

Reference Books:

- R1.** Solar Energy Principles of Thermal Collection and Storage, Sukhatme, S. P. Tata McGraw Hill Publishing Company Ltd. New Delhi, 2009.
- R2.** Renewable Energy Sources and Emerging Technologies by D.P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Pvt. Limited New Delhi, 2011.

Web Resources:

- 1. <https://mnre.gov.in>
- 2. <https://niwe.res.in>
- 3. <https://www.irena.org>

2599103	M.Tech., I-SEMESTER HYDROGEN AND FUEL CELL TECHNOLOGIES (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the properties and various production methods of hydrogen.
- CO2.** Describe hydrogen storage techniques, safety aspects, and applications.
- CO3.** Analyse the principles, thermodynamics, and performance of fuel cells.
- CO4.** Compare different types of fuel cells and their characteristics.
- CO5.** Evaluate the applications, economics, and environmental benefits of hydrogen and fuel cells.

SYLLABUS:

UNIT-I: HYDROGEN – BASICS AND PRODUCTION TECHNIQUES (09 Periods)

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

UNIT-II: HYDROGEN STORAGE AND APPLICATIONS (09 Periods)

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

UNIT-III: FUEL CELLS (09 Periods)

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

UNIT-IV: TYPES OF FUEL CELLS (09 Periods)

Introduction to Fuel Cell Classification, Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Proton Exchange Membrane Fuel Cell (PEMFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC), Comparative Analysis and Recent Developments – Relative merits and demerits.

UNIT-V: APPLICATION OF FUEL CELL AND ECONOMICS (09 Periods)

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

Total Periods: 45

Textbooks:

- T1.** Fuel Cells, Engines and Hydrogen, Barclay F.J., Wiley, 2009.
- T2.** Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen Elsevier, UK 2005.
- T3.** Fuel Cells: Theory and Application, Hart A.B. and G.J. Womack, Prentice Hall, New York Ltd., 1989.

Reference Books:

- R1.** The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA, 2002.
- R2.** Fuel Cell and Their Applications, Wiley-Vch, Kordesch K. and G. Simader, Germany, 1996.
- R3.** Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn, Well Corporation, Oklahoma, 2005.
- R4.** Fuel Cells – Principles and Applications, Viswanathan B. and Aulice Scibioh.M.

Web Resources:

1. <https://www.energy.gov/eere/fuelcells>
2. <https://www.iea.org/topics/hydrogen>
3. <https://www.fchea.org>

2599104	M.Tech., I-SEMESTER SOLAR ENERGY TECHNOLOGIES (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1. Explain the principles of solar radiation, its measurement, and analyze the performance characteristics of various solar collectors.
- CO2. Describe and evaluate different solar thermal technologies and their applications in heating, cooling, desalination, and energy storage systems.
- CO3. Illustrate the fundamental semiconductor physics and assess the efficiency parameters influencing solar photovoltaic cell performance.
- CO4. Design and analyse solar PV systems for standalone, hybrid, and grid-connected applications considering system reliability, performance, and economic factors.
- CO5. Apply the principles of solar passive architecture to develop energy-efficient building designs ensuring thermal comfort through natural heating and cooling.

SYLLABUS:

UNIT-I: SOLAR RADIATION AND COLLECTORS (09 Periods)

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

UNIT-II: SOLAR THERMAL TECHNOLOGIES (09 Periods)

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

UNIT-III: SOLAR PV FUNDAMENTALS (09 Periods)

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

UNIT-IV: SPV SYSTEM DESIGN AND APPLICATIONS (09 Periods)

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

UNIT-V: SOLAR PASSIVE ARCHITECTURE (09 Periods)

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

Total Periods: 45

Textbooks:

- T1.** Principles of Solar Engineering, Goswami D.Y., Kreider, J. F. and Francis., Taylor and Francis, 2000.
- T2.** Solar Photovoltaics – Fundamental Technologies and Applications, Chetan Singh Solanki, PHI Learning Private Limited, 2011.

Reference Books:

- R1.** Solar Energy – Principle of Thermal Storage and collection, Sukhatme S.P. Nayak.J.P, Tata McGraw Hill, 2008.
- R2.** Solar Energy International, “Photovoltaic – Design and Installation Manual” New Society Publishers, 2006.
- R3.** Photovoltaic Systems Engineering, Roger Messenger and Jerry Vnetre, CRC Press, 2010.

Web Resources:

1. <https://www.nrel.gov>
2. <https://www.solarenergy.org>
3. <https://mnre.gov.in>

2599105	M.Tech., I-SEMESTER PROCESS MODELLING AND SIMULATION IN RENEWABLE ENERGY SYSTEMS (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the principles, types, and computational techniques used in modelling and simulation of energy systems.
- CO2.** Develop mathematical models for mechanical, electrical, thermal, fluid flow, and chemical systems using first-principle and empirical approaches.
- CO3.** Apply numerical and computational methods such as Euler's, Runge-Kutta, and Finite Element Techniques for solving lumped and distributed parameter models.
- CO4.** Analyze and optimize energy system performance using linear and nonlinear optimization methods with appropriate constraints.
- CO5.** Design and simulate energy systems using econometric and sensitivity analysis tools to assess uncertainty and improve decision-making.

SYLLABUS:

UNIT-I: INTRODUCTION TO MODELLING (09 Periods)

Types and classification, uses, limitations, advantages of modelling; Review of computational tools/techniques used for mathematical modelling including solutions for non-linear equations, system of simultaneous equations, conservation principles, thermodynamic principles.

UNIT-II: INTRODUCTION TO DEVELOPMENT BASED ON FIRST PRINCIPLES

(09 Periods)

Steady state and dynamic, Lumped and distributed parameter models, Block diagrams and computer simulation. Modeling of Process elements consisting of Mechanical (translational and rotational), Electrical, Electro- mechanical, Fluid flow, Thermal and Chemical reaction system elements.

Development of Models: Grey box models, Empirical model building, Statistical model calibration and validation. Population balance models, examples of energy system modeling, static and dynamic modeling; Modeling errors, accuracy and methods of model validation.

UNIT-III: SOLUTION STRATEGIES FOR LUMPED PARAMETER MODELS

(09 Periods)

Solution methods for initial value and boundary value problems, Euler's method, R-K method, Shooting method, Finite difference methods. Finite element and Finite volume methods. Solving the problems using MATLAB / SCILAB.

UNIT-IV: OPTIMIZATION

(09 Periods)

Problem formulation with practical examples from energy system, constrained optimization and unconstrained problems: necessary and sufficiency conditions. Uses of Linear Programming technique for solution of problems related to Energy systems/ case studies. Constrained Optimization, Lagrange multipliers, constrained variations, Kuhn-Tucker conditions, Case studies of optimization in Energy systems problems, Dealing with uncertainty- probabilistic techniques.

UNIT-V: ENERGY SYSTEMS SIMULATION OPTIMIZATION

(09 Periods)

Objectives / constraints, Problem formulation. Unconstrained problems, Necessary & Sufficiency conditions.

Econometric Modeling: Input Output models considering energy budgeting, Sensitivity analysis, importance of parametric analysis and tools for sensitivity analysis

Total Periods: 45

Textbooks:

- T1.** Engineering Optimization: Theory and Practice, Rao S. S. New Age International, 2004, Third Edition.
- T2.** A Guide to Econometrics, Kennedy P., Wiley-Blackwell, 2008, Sixth Edition.
- T3.** Energy Systems Analysis for Developing Countries, Meier P., Springer Verlag, 1984.

Reference Books:

- R1.** Engineering Optimization: Methods and Applications, Ravindran A. Ragsdell K. M. and Reklaitis G. V., Wiley, 2006, Second Edition.
- R2.** Applied Systems Analysis: Engineering Planning and Technology Management, Neufville R De. (1990). McGraw Hill.
- R3.** Hangos, K., & Cameron, I. (2001). Process modelling and model analysis. Academic Press.
- R4.** James, J. C. (1989). Process modeling, simulation and control for Chemical Engineers. McGraw Hill.
- R5.** Close, C. M., & Frederick, D. K. (2002). Modelling and analysis of dynamic systems John Wiley & Sons.

Web Resources:

1. <https://www.nrel.gov>
2. <https://www.energyexemplar.com>
3. <https://www.mathworks.com>

2599106	M.Tech., I-SEMESTER ENERGY STORAGE TECHNOLOGY (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the need for energy storage and compare various storage technologies based on their principles and applications.
- CO2.** Analyze the principles and performance of thermal and mechanical energy storage systems using energy and energy concepts.
- CO3.** Evaluate the characteristics and performance of different battery technologies and hydrogen-based energy storage systems.
- CO4.** Examine the working, modelling, and applications of various fuel cell types for power and transportation.
- CO5.** Apply energy storage technologies for practical uses such as food preservation, waste heat recovery, and solar energy systems.

SYLLABUS:

UNIT-I: ENERGY AVAILABILITY

(09 Periods)

Demand and storage, Need for energy storage, Different types of energy storage; Mechanical, Chemical, Electrical, Electrochemical, Biological, Magnetic, Electromagnetic, Thermal; Comparison of energy storage technologies.

UNIT-II: THERMAL AND MECHANICAL ENERGY STORAGE

(09 Periods)

Thermal Storage: Principles and applications, Sensible and Latent heat, Phase change materials; Energy and exergy analysis of thermal energy storage, solar energy and thermal energy storage, case studies.

Mechanical Energy Storage: Flywheel and compressed air storage; Pumped hydro storage; Hydrogen energy storage, Capacitor and super capacitor, Electrochemical Double Layer Capacitor: Principles, performance and applications

UNIT-III: ELECTROCHEMICAL AND HYDROGEN ENERGY STORAGE

(09 Periods)

Electrochemical Energy Storage: Battery – fundamentals and technologies, characteristics and performance comparison: Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries.

Hydrogen Energy Storage: Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells; Thermodynamics of fuel cells

UNIT-IV: FUEL CELLS

(09 Periods)

AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell, Fuel cell performance, characterization and modeling; Fuel cell system design and technology, applications for power and transportation.

UNIT-V: APPLICATIONS OF ENERGY STORAGE

(09 Periods)

Food preservation, Waste heat recovery, Solar energy storage: Greenhouse heating; Drying and heating for process industries.

Total Periods: 45

Textbooks:

- T1. Thermal Energy Storage: Systems and Applications, Dincer I., and Rosen M. A., Wiley Eastern, 2011.
- T2. Energy Storage: Fundamentals, Materials and Applications, Huggins R. A., Springer, 2015.
- T3. Fuel Cell Fundamentals, O'Hayre R., Cha S., Colella W., and Prinz F. B. Wiley Eastern, 2009, Second Edition.

Reference Books:

- R1. Chemical and Electrochemical Energy System, Narayan R. and Viswanathan B., Universities Press 2011.
- R2. Battery Systems Engineering, Rahn C. D. and Wang C., Wiley Eastern, 2013, First Edition.
- R3. Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Moseley P. T., and Garche J., Elsevier Science, 2014.

Web Resources:

1. https://www.energystorage.org/resources?utm_source
2. https://irecusa.org/our-work/energy-storage/?utm_source
3. https://www.nrel.gov/storage?utm_source

2599107	M.Tech., I-SEMESTER ENERGY CONSERVATION BY WASTE HEAT RECOVERY (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the sources of waste heat, its quality, and methods for optimal utilization of fossil fuels through combined and cogeneration systems.
- CO2.** Analyze energy principles and evaluate the performance of different industrial heat recovery systems and heat exchangers.
- CO3.** Describe the design and operation of waste heat boilers and heat pipe systems used for heat recovery applications.
- CO4.** Examine various waste heat utilization techniques in power generation, HVAC, and thermo electric systems.
- CO5.** Assess waste heat recovery and energy storage systems through quantitative, economic, and techno-feasibility analyses.

SYLLABUS:

UNIT-I: INTRODUCTION

(09 Periods)

Heat losses, its quality and quantity, potential for energy conservation. Waste heat sources: steam, compressed air, refrigeration, flue gases, furnace/air stream exhaust, high grade heat, low grade heat.

Optimal utilization of fossil fuels: Total energy approach; Coupled cycles and combined plants; Cogeneration systems.

UNIT-II: EXERGY ANALYSIS

(09 Periods)

Utilization of industrial waste heat; Properties of exhaust gas; Gas-to- gas, gas-to- liquid heat recovery systems; Recuperators and regenerators; Shell and tube heat exchangers; Spiral tube and plate heat exchangers.

UNIT-III: WASTE HEAT BOILERS

(09 Periods)

Various types and design aspects. Heat pipes: theory and applications in waste heat recovery.

UNIT-IV: PRIME MOVERS

(09 Periods)

Sources and uses of waste heat; Fluidized bed heat recovery systems; Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems; Thermoelectric system to recover waste heat; Heat pump for energy recovery; Heat recovery from incineration plants.

UNIT-V: WASTE HEAT RECOVERY CALCULATIONS AND NEED FOR ENERGY STORAGE

(09 Periods)

Waste Heat Recovery Calculations: Quantifying available heat (kWh), Pinch analysis, typical energy costs/construction costs, pay back analysis, thermo-economic viability.

Need for Energy Storage: Thermal, electrical, magnetic and chemical storage systems.

Total Periods: 45

Textbooks:

- T1.** Process Heat Transfer, Hewitt, G. F., Shires, G. L., and Bott, T. R., CRC Press, Florida, 1993.
- T2.** Process Heat Transfer. Flynn, A. M., Akashige, T., & Theodore, L., John Wiley & Sons, 2018.
- T3.** Energy Conversion, Goswami, D. Y., and Kreith, F. CRC Press, 2007.

Reference Books:

- R1.** Process Heat Transfer: Principles, Applications and Rules of Thumb. Serth, R. W., & Lestina, T., Academic press, 2014.
- R2.** Small and Micro Combined Heat and power (CHP) systems: Advanced Design, Performance, Materials and Applications, Beith, R., Elsevier, 2018.
- R3.** Wealth from waste, Khanna S., & Mohan, K., Tata Energy Research Institute, 2019.

Web Resources:

- 1. <https://www.energy.gov/sites/prod/files/2014/05/f15/35876.pdf>
- 2. <https://www.ipieca.org/resources/energy-efficiency-compendium>
- 3. <https://www.sigmathermal.com/how-do-waste-heat-recovery-systems-work>

2599108	M.Tech., I-SEMESTER DEVELOPING ENERGY EFFICIENCY AND RENEWABLE ENERGY PROJECTS (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the key drivers, motivation, and framework for developing energy efficiency and renewable energy projects within policy and regulatory environments.
- CO2.** Analyze pre-investment activities such as site selection, technology assessment, feasibility studies, and stakeholder engagement for successful project planning.
- CO3.** Evaluate project implementation processes including procurement, commissioning, risk management, and performance monitoring.
- CO4.** Examine the role of policies, sustainability considerations, and community participation in promoting renewable and energy efficiency projects.
- CO5.** Apply project development principles to real-world case studies on renewable energy, energy efficiency, and environmental management projects.

SYLLABUS:

UNIT-I: PROJECT MOTIVATION (09 Periods)

Key drivers-pre-development, gauging market characteristics that provide motivation for the project and assessment of market readiness, Project development framework, Essential elements, project development environment including existing policy environment- relevant codes (such as ECBC).

UNIT-II: PRE-INVESTMENT PHASE (09 Periods)

Assessing Potential Sites, identifying partners, Assessment of commercially available energy technologies for improving energy efficiency and harnessing renewable energy, preparation of business plan (that includes feasibility study, engineering design, Financial closure, permitting activities and related documentation and agreements), consensus with project stakeholders

UNIT-III: IMPLEMENTATION PHASE (09 Periods)

Procurement, land acquisition, site preparation, construction, installation, commissioning of the project, operation of the facility, Actual implementation of the business plan, Monitoring and evaluation of the business and the project performance, Issues in implementation of energy efficiency and renewable energy projects, Essential areas for strong project development in renewable energy - site, resource, permits, technology, team and capital, Size and diversity of potential project sponsors and also of projects in the field of renewable energy and energy efficiency.

Risks Factor: Risk in energy efficiency and renewable energy projects and appropriate de-risking/ mitigation measures and approaches, dispute resolution,

UNIT-IV: ROLE OF POLICIES, ISSUES AND CHALLENGES (09 Periods)

Role of Policies: Policy and support measures in promoting energy efficiency and renewable energy, developing community driven projects, developing projects for improving energy access, socially inclusive projects,

Issue And Challenges: Issues in using public lands for developing renewable energy projects, Various considerations in selecting local versus imported technologies, Challenges in implementing energy efficiency in public sector within government financial and other regulations, Environmental impact and sustainability assessment of energy efficiency and

renewable energy projects and projects while addressing environmental issues, Utility scale versus local projects.

UNIT-V: EXAMPLES AND CASE STUDIES

(09Periods)

Developing PV/wind power projects, projects for enhanced LED use in domestic, commercial, institutional and industrial sectors, environmental management projects.

Total Periods: 45

Textbooks:

- T1.** Renewable Energy Project Development Under the Clean Development Mechanism: A Guide for Latin America, Lokey, E. Routledge, 2012.
- T2.** Framework for Project Development in the Renewable Energy Sector (No. NREL/TP-7A40-57963). National Renewable Energy Lab. (NREL), Springer, 2013.
- T3.** Guide to Developing a Community Renewable Energy Project in North America. Ontario Sustainable Energy Association, Montreal, Canada, 2010.

Reference Books:

- R1.** 16 Case Studies on the Deployment of Photovoltaic Technologies in Developing Countries. International Energy Agency IEA-PVPS.T9-07, 2003.
- R2.** Developing Renewable Energy Projects Larger Than 10 MWs at Federal Facilities, Report DOE/GO- 102013-3915, US Department of Energy Guide, 2003.
- R3.** Thomsen, K. (2014). Offshore wind: a comprehensive guide to successful offshore wind farm installation, Academic Press.

Web Resources:

1. <https://unece.org/sites/default/files/2023>
2. <https://www.epa.gov/greenpower/renewable-energy-project-development-toolbox>
3. <https://www.epa.gov/greenpower/toolbox-renewable-energy-project-development>

2599151	M.Tech., I-SEMESTER FUELS LAB (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Determine the physical and chemical properties of fuels and lubricants, including flash point, fire point, viscosity, and carbon residue.
- CO2.** Measure the calorific value of solid, liquid, and gaseous fuels using appropriate laboratory equipment.
- CO3.** Analyze fuel quality through standardized tests such as ASTM distillation, cloud point, and pour point for safe and efficient energy use.
- CO4.** Able to apply appropriate tools and techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** Work as a team and communicate results in an effective way.
- CO6.** make decisions as an individual or as team member to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

List of Experiments:

1. Determination of Flash Point and Fire Point of Liquid Fuels/Lubricants Using ables Apparatus.
2. Determination of Flash Point and Fire Point of Liquid Fuels/Lubricants Using Pesky Martens Test.
3. Carbon Residue Test
4. Determination of Viscosity of Liquid Lubricants and Fuels using Saybolt Viscometer.
5. Determination of Viscosity of Liquid Lubricants and Fuels using red wood viscometer-I & II.
6. Determination of Viscosity of Liquid Lubricants and Fuels using Engler viscometer.
7. Determination of calorific value of gaseous fuels using Junkers gas calorimeter.
8. Determination of calorific value of solid/liquid fuels using bomb calorimeter.
9. ASTM distillation test apparatus.
10. Cloud and Pour point apparatus.

Reference Books / Laboratory Manuals:

- R1. ASTM Standards on Petroleum Products and Lubricants, ASTM International (for all testing procedures).
- R2. Thermodynamics: An Engineering Approach, Cengel, Y.A. and Boles, M.A., McGraw Hill Education.

2599152	M.Tech., I-SEMESTER SOLAR ENERGY ENGINEERING LAB (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Analyse the performance of solar PV modules under varying operating conditions.
- CO2.** Evaluate the efficiency and power flow of stand-alone PV systems with battery storage.
- CO3.** Examine the thermal performance of flat plate and parabolic trough solar collectors.
- CO4.** Able to apply appropriate tools and techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** Work as a team and communicate results in an effective way.
- CO6.** Make decisions as an individual or as team member to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes

List of Experiments:

1. Determination of I-V & P-V Characteristics of a Solar PV Panel
2. Determination of I-V & P-V Characteristics of Series and Parallel combination of PV Modules
3. Determination of Characteristics of PV Module With a variation of the Tilt angle
4. Effect of Shading on Solar PV Module Output Power
5. Power Flow calculation of Stand-Alone PV System of DC Load with Battery
6. Charging and Discharging Characteristics of Battery
7. Determination of parameters of Flat Plate Collector – Forced Mode
8. Determination of parameters of Flat Plate Collector – Thermo siphon Mode
9. Determination of parameters of Flat Plate Collector for different mass flow rate
10. Determination of parameters of Flat Plate Collector for different radiation
11. Determination of parameters of Flat Plate Collector – Forced mode of flow at different wind speeds
12. Determination of parameters of Flat Plate Collector for Different Tilt Angle
13. Determination of parameters of Parabolic Trough Collector
14. Determination of parameters of Parabolic Trough Collector for different mass flow rate

Virtual Lab Experiments:

Link: <https://vlab.amrita.edu/index.php?sub=77&brch=298>

1. Solar Energy Measurements - Pyrheliometer
(Direct Normal Irradiance (DNI) and Concentrating Solar Thermal Site Analysis)
2. Solar Energy Measurements - Pyrometer (Global Horizontal Irradiance (GHI))
Solar Energy Measurements
3. To study the various solar irradiance measurements using pyrheliometer and pyranometers
(Comparing the Global horizontal irradiance, diffuse horizontal irradiance and direct normal irradiance levels.)
4. Solar PV Tracker
(Determining I-V and P-V curves and the Maximum Power Point for a Solar PV Cell under Varying Irradiance)
5. External Compound Parabolic Collector (XCPC) - Oil

- (Optimizing Flow Rate for Maximum Heat Absorption using Thermal Oil)
6. External Compound Parabolic Collector (XCPC) - Water
(Optimizing Flow Rate for Maximizing Heat Absorption using Water)
 7. Parabolic Trough - Angle
(Sensitivity to Solar Tracking Accuracy)
 8. Parabolic Trough -Flow Rate
(Optimizing Flow Rate for Maximum Heat Absorption using Water)

Reference Books/ Laboratory Manuals:

- R1. Principles of Solar Engineering, Kreith, F. and Kreider, J.F., Hemisphere Publishing Corporation.
- R2. Experiments in Solar Energy, K. Sukhatme Lab Manual, Tata McGraw Hill.

2599153	M.Tech., I-SEMESTER BIO ENERGY LAB (RENEWABLE ENERGY)	L	T	P	C
		0	1	2	2

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Analyze the physical and chemical characteristics of various biomass feedstocks for bioenergy applications.
- CO2.** Demonstrate and evaluate biofuel production processes such as biogas, bioethanol, and biodiesel generation.
- CO3.** Assess the performance and emission characteristics of biofuels and apply bioenergy conversion technologies for sustainable energy systems.
- CO4.** Able to apply appropriate Tools and Techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** Work as a team and communicate results in an effective way.
- CO6.** Make decisions as an individual or as team member to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

List of Experiments:

1. Proximate Analysis of Biomass
2. Determination of Calorific Value of Biomass
3. Ultimate Analysis of Biomass
4. Design and Operation of a Laboratory-Scale Biogas Digester
5. Measurement of Methane Content in Biogas
6. Production of Bioethanol from Biomass
7. Determination of Ethanol Concentration
8. Measurement of methane content in biogas using a gas analyser.
9. Effect of parameters such as temperature, pH, and retention time on biogas yield.
10. Performance Evaluation of Biodiesel in a CI Engine (Demonstration)

Textbooks and Reference Books:

1. Bioenergy: Biomass to Biofuels and Waste to Energy, Anju Dahiya, Academic Press (Elsevier), 2020, Second Edition.
2. Biomass, Bioenergy and Bio economy: Sustainability and Resource Management, S. K. Sharma, R. K. Singh, Springer Nature, 2022, First Edition.
3. Biofuel Production, Performance and Emission Optimization, Manjunath Patel G. C., Ajith B. S., Jagadish, Arun Kumar Shettigar, Olusegun David Samuel, CRC Press, 2023, First Edition.

2599171	M.Tech., I-SEMESTER	L	T	P	C
	RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (MANDATORY COURSE)	2	0	0	2

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Demonstrate the research process, types and methods, use data correctly, follow ethical rules, and use proper citation styles.
- CO2.** Apply appropriate data collection methods, identify data types and sources, ensure quality, and follow ethical practices using suitable tools.
- CO3.** Apply multivariate analysis and experimental design to study cause-effect relationships, ensure measurement validity, and write structured research papers and proposals.
- CO4.** Demonstrate the concept, evolution, and types of Intellectual Property Rights (IPR), recognize global IPR practices and institutions like WIPO, WTO, and UNESCO, and identify key agreements, trade secrets, and biodiversity-related rights.
- CO5.** Demonstrate the concept, features, and benefits of patents; identify types of patent applications and the filing process; and explain the roles of patent agents, licensing, and patent regulations.

SYLLABUS:

UNIT-I: FUNDAMENTALS OF RESEARCH METHODOLOGY (09 Periods)

Overview of research process and design - Types of Research - Approaches to Research (Qualitative vs Quantitative) - Observation studies, Experiments and Surveys - Use of Secondary and exploratory data to answer the research question - Importance of Reasoning in Research and Research ethics - Documentation Styles (APA/IEEE etc.) - Plagiarism and its consequences.

UNIT-II: DATA COLLECTION AND SOURCES (09 Periods)

Importance of Data Collection - Types of Data - Data Collection Methods - Data Sources - primary, secondary and Big Data sources - Data Quality & Ethics - Tools and Technology for Data Collection.

UNIT-III: DATA ANALYSIS AND REPORTING (09 Periods)

Overview of Multivariate analysis - Experimental research, cause-effect relationship, and development of hypotheses- Measurement systems analysis, error propagation, and validity of experiments - Guidelines for writing abstracts, introductions, methodologies, results, and discussions - Writing Research Papers & proposals.

UNIT-IV: UNDERSTANDING INTELLECTUAL PROPERTY RIGHTS (09 periods)

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V: PATENTS (09 Periods)

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification - Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents

Total Periods: 45

Textbooks:

- T1. Research Methodology: An introduction for Science & Engineering students, Stuart Melville and Wayne Goddard, Juta and Company Ltd, 2004
- T2. Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, Catherine J. Holland, Entrepreneur Press, 2007.

References Books:

- R1. Business Research Methods, Cooper Donald R, Schindler Pamela S and Sharma JK, Tata McGraw Hill Education, 2012, Eleventh Edition,
- R2. Research Methodology: A Step-by-Step Guide for Beginners, David Hunt, Long Nguyen, Matthew Rodgers, Wiley, 2007.
- R3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, Deborah E. Bouchoux, Cengage, 2024, Sixth Edition,
- R4. The Craft of Research, Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, University of Chicago Press, 2024, Fifth Edition.
- R5. Professional Programme Intellectual Property Rights, Law and practice, The Institute of Company Secretaries of India, Statutory body under an Act of parliament, September, 2013.

Web Resources:

1. Research Methodology and Data Analysis courses, Coursera / edX
2. Latest journals on research design and statistics, Springer Link & ScienceDirect
3. Free access to research papers Google Scholar
4. Open-access research methodology resources, NCBI Bookshelf
5. For fundamentals of hypothesis testing, regression, and ANOVA. Khan Academy (Statistics & Probability)

2599181	M.Tech., I-SEMESTER	L	T	P	C
	ENGLISH FOR RESEARCH PAPER WRITING (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE-I)	2	0	0	0

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Demonstrate proficiency in academic English by applying MAP principles, using clear, precise, and objective language, structuring coherent paragraphs, integrating references, and employing paraphrasing and appropriate tone in writing.
- CO2.** Exhibit critical reading skills to analyze academic texts, differentiate between article types, identify arguments and methodologies, evaluate findings, and make effective notes.
- CO3.** Apply advanced grammar and punctuation to construct clear, accurate, and complex sentences with proper voice, tense consistency, subject-verb agreement, and unambiguous references.
- CO4.** Revise and refine written work by editing for clarity, coherence, and grammar; proofread for accuracy; and apply effective strategies for professional correspondence and creative writing.
- CO5.** Demonstrate digital literacy by critically evaluating online content, using AI tools ethically in research writing, generating accurate citations, and practicing plagiarism-free writing with awareness of fair practices.

SYLLABUS:

UNIT-I: FUNDAMENTALS OF ACADEMIC ENGLISH (05 Periods)

Academic English - MAP (Message-Audience-Purpose) - Language Proficiency for Writing - Key Language Aspects - Clarity and Precision - Objectivity - Formal Tone - Integrating References - Word order - Sentences and Paragraphs - Link Words for Cohesion - Avoiding Redundancy / Repetition - Breaking up long sentences - Structuring Paragraphs - Paraphrasing Skills – Framing Title and Sub-headings

UNIT-II: READING SKILLS FOR RESEARCHERS (06 Periods)

Reading Academic Texts - Critical Reading Strategies - Skimming and Scanning - Primary Research Article vs. Review Article - Reading an Abstract - Analyzing Research Articles - Identifying Arguments - Classifying Methodologies - Evaluating Findings - Making Notes

UNIT-III: GRAMMAR REFINEMENT FOR RESEARCH WRITING (06 Periods)

Advanced Punctuation Usage - Grammar for Clarity - Complex Sentence Structures - Active-Passive Voice - Subject-Verb Agreement - Proper Use of Modifiers - Avoiding Ambiguous Pronoun References - Verb Tense Consistency - Conditional Sentences.

UNIT-IV: MASTERY IN REFINING WRITTEN CONTENT/EDITING SKILLS

(07 Periods)

Effective Revisions - Restructuring Paragraph - Editing vs Proofreading, Editing for Clarity and Coherence - Rectifying Sentence Structure Issues - Proofreading for Grammatical Precision – Spellings - Tips for Correspondence with Editors - Critical and Creative Phases of Writing.

UNIT-V: TECHNOLOGY AND LANGUAGE FOR RESEARCH

(06 Periods)

Digital Literacy and Critical Evaluation of Online Content - Technology and Role of AI in Research Writing – Assistance in Generating Citations and References - Plagiarism and Ethical Considerations – Tools and Awareness – Fair Practices

Total Periods: 30

Textbooks:

- T1. Academic Writing: A Handbook for International Students. Routledge, Bailey. S. London and New York: 2015.
- T2. English for Writing Research Papers, Adrian Wallwork, Springer New York Dordrecht Heidelberg London, 2011.

Reference books:

- R1. Writing for Academic Success, Craswell, G., Sage Publications, 2004.
- R2. Writing With Power, Peter Elbow, E-book, Oxford University Press, 2007
- R3. Writing Academic English, Oshima, A. & Hogue, A., Addison-Wesley, New York, 2005
- R4. Academic Writing for Graduate Students: Essential Skills and Tasks, Swales, J. & C. Feak, Michigan University Press, 2012.
- R5. Writing for Science, Goldbort R., Yale University Press (available on Google Books), 2006
- R6. How to Write and Publish a Scientific Paper, Day R., Cambridge University Press, 2006

Web Resources:

1. <https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ge04/>
2. https://onlinecourses.swayam2.ac.in/ntr24_ed15/preview
3. "Writing in the Sciences" – Stanford University (MOOC on Coursera)
<https://www.coursera.org/learn/sciwrite>
4. Academic Phrasebank – University of Manchester
<http://www.phrasebank.manchester.ac.uk>
5. OWL (Online Writing Lab) – Purdue University,
<https://owl.purdue.edu>
(Resources on APA/MLA formats, grammar, structure, paraphrasing)
6. Zotero or Mendeley (Reference Management Tools) – Useful for managing citations and sources.

2512181	M.Tech., I-SEMESTER	L	T	P	C
	DISASTER MANAGEMENT (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE - I)	2	0	0	0

PRE-REQUISITES: NIL

COURSE OUT COMES:

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

- CO1.** Identify and map disaster-prone areas and understand the epidemiological consequences of disasters.
- CO2.** Define and distinguish between hazards and disasters, and explain their types, nature, and impacts.
- CO3.** Assess the economic, social, and ecological repercussions of major natural and man-made disasters.
- CO4.** Apply risk assessment methods and propose disaster risk reduction strategies at local, national, and global levels.
- CO5.** Demonstrate knowledge of disaster preparedness tools such as remote sensing, meteorological data, risk evaluation, and community awareness.

SYLLABUS:

UNIT-I: INTRODUCTION

(06 Periods)

Disaster Prone Areas in India - Study of Seismic Zones - Areas Prone to Floods and Droughts, Landslides and Avalanches - Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami - Post-Disaster Diseases and Epidemics.

UNIT-II: REPERCUSSIONS OF DISASTERS AND HAZARDS

(06 Periods)

Economic Damage - Loss of Human and Animal Life - Destruction of Ecosystem - Natural Disasters - Earthquakes, Volcanism, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster - Nuclear Reactor Meltdown - Industrial Accidents - Oil Slick and Spills - Outbreaks of Disease and Epidemics War and Conflicts

UNIT-III: DISASTER PREPAREDNESS AND MANAGEMENT

(06 Periods)

Preparedness - Monitoring of Phenomena - Triggering a Disaster or Hazard - Evaluation of Risk- Application of Remote Sensing - Data from Meteorological and Other Agencies -Media Reports- Governmental and Community Preparedness

UNIT-IV: RISK ASSESSMENT

(06 Periods)

Disaster Risk -Concept and Elements, Disaster Risk Reduction - Global and National Disaster Risk Situation -Techniques of Risk Assessment – Global Co-Operation in Risk Assessment and Warning - People’s participation Risk Assessment – Strategies for Survival

UNIT-V: DISASTER MITIGATION

(06 Periods)

Meaning, Concept and Strategies of Disaster Mitigation – Emerging Trends in Mitigation - Structural Mitigation and Non- Structural Mitigation - Programs of Disaster Mitigation in India

Total Periods: 30

Textbooks:

- T1. Disaster Management, Gupta, H. K, Universities Press, 2003
- T2. Natural Hazards and Disaster Management, Singh, R. B., Rawat Publications, 2006.

Reference Books:

- R1. Introduction to International Disaster Management, Coppola, D. P., Elsevier, 4th ed., 2020.
- R2. Science and Technology in Disaster Risk Reduction in Asia, Shaw, R., & Izumi, T., Springer, 2022.
- R3. Handbook of Hazards and Disaster Risk Reduction and Management, Wisner, B., Gaillard, J. C., & Kelman, I., Routledge, 2nd ed., 2021.
- R4. Disaster Management in India: Policy, Issues and Perspectives, Saini, V. K., Sage India, 2021.
- R5. Disaster by Choice: How Our Actions Turn Natural Hazards into Catastrophes, Kelman, I., Oxford University Press, 2022
- R6. Disaster Mitigation: Experiences and Reflections, Sahni, P. & Dhameja, A., Prentice Hall of India, 2004.

Web Resources:

1. <https://ndma.gov.in> – official guidelines, reports, and policy frameworks.
2. <https://www.undrr.org> – Sendai Framework, global risk reduction strategies.
3. <https://www.gdacs.org> – real-time disaster alerts
4. <https://www.undrr.org> – Sendai Framework, global risk reduction strategies.

2598181	M.Tech., I-SEMESTER ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE - I)	L	T	P	C
		2	0	0	0

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

- CO1.** Illustrate traditional knowledge, its nature, characteristics, and scope
- CO2.** Demonstrate the need for protecting traditional knowledge and its significance in the global economy
- CO3.** Explain the legal framework and policies related to traditional knowledge protection
- CO4.** Apply traditional knowledge in different sectors, such as engineering, medicine, agriculture, and biotechnology
- CO5.** Analyze the importance of traditional knowledge in various contexts, including its historical impact and social change, relationship between traditional knowledge and intellectual property rights, including patents and non-IPR mechanisms

SYLLABUS:

UNIT-I: INTRODUCTION TO TRADITIONAL KNOWLEDGE (06 Periods)

Definition, Nature and characteristics, scope and importance - Kinds of traditional knowledge - Physical and social contexts in which traditional knowledge develop - Historical impact of social change on traditional knowledge systems - Indigenous Knowledge (IK) – Characteristics - traditional knowledge vis-à-vis indigenous knowledge -Traditional knowledge Vs western knowledge, traditional knowledge vis-à-vis formal knowledge

UNIT-II: PROTECTION OF TRADITIONAL KNOWLEDGE (06 Periods)

Need for protecting traditional knowledge - Significance of TK Protection - Value of TK in global economy - Role of Government to harness TK.

UNIT-III: LEGAL FRAME WORK AND TRADITIONAL KNOWLEDGE (06 Periods)

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 - Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act).
The Biological Diversity Act 2002 and Rules 2004 - the protection of traditional knowledge bill, 2016 Geographical Indicators Act 2003.

UNIT-IV: TRADITIONAL KNOWLEDGE AND INTELLECTUAL PROPERTY

(06 Periods)

Systems of traditional knowledge protection - Legal concepts for the protection of traditional knowledge - Certain non-IPR mechanisms of traditional knowledge protection - Patents and traditional knowledge - Strategies to increase protection of traditional knowledge -Global legal FORA for increasing protection of Indian Traditional Knowledge.

UNIT-V: TRADITIONAL KNOWLEDGE IN DIFFERENT SECTORS (06 Periods)

Traditional knowledge and Engineering - Traditional medicine system - TK and Biotechnology - TK in Agriculture - Traditional societies depend on it for their food and healthcare needs - Importance of conservation and sustainable development of environment - Management of biodiversity, Food security of the country and protection of TK

Total Periods: 30

Textbooks:

- T1. Introduction to Indian Knowledge System: Concepts and Applications, Mahadevan, B., Bhat Vinayak Rajat, and Nagendra Pavana R.N., PHI Learning Pvt. Ltd., Delhi, 2022 (1st Edition).
- T2. Traditional Knowledge System and Technology in India, Basanta Kumar Mohanta and Vipin Kumar Singh, Pratibha Prakashan, 2012 (1st Edition).

Reference Books

- R1. Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi 2006.
- R2. On Astronomy in Ancient India, Kak, S.C. Indian Journal of History of Science, 22(3), 1987
- R3. Indian Astronomy: A Source Book, Subbarayappa, B.V. and Sarma, K.V. Nehru Centre, Mumbai, 1985.
- R4. History of Technology in India, Vol. I, Bag, A.K., Indian National Science Academy, New Delhi, 1997.
- R5. Indian Architecture, Acarya, P.K. Munshiram Manoharlal Publishers, New Delhi, 1996.
- R6. Public Administration in Ancient India, Banerjea, P. Macmillan, London, 1961.
- R7. Indian Knowledge Systems Vol – I & II, Kapoor Kapil, Singh Avadhesh, Indian Institute of Advanced Study, Shimla, H.P., 2022

Web Resources:

1. <https://www.youtube.com/watch?v=LZP1StpYEPM>
2. <http://nptel.ac.in/courses/12110600>

2599201	M.Tech., II-SEMESTER WIND ENERGY TECHNOLOGY (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: INTRODUCTION TO RENEWABLE ENERGY SYSTEMS

Course Outcomes:

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

- CO1.** Analyze wind characteristics and evaluate wind energy potential for a given site.
- CO2.** Design and select appropriate wind energy conversion systems for different applications.
- CO3.** Evaluate the performance and efficiency of wind turbines and their components.
- CO4.** Demonstrate knowledge of wind farm planning, installation, and maintenance.
- CO5.** Assess the techno-economic feasibility and environmental impact of wind energy systems.

SYLLABUS:

UNIT-I: INTRODUCTION TO WIND ENERGY (9 Periods)

Wind characteristics – origin and nature of wind – atmospheric circulations – wind speed distribution and statistics – Weibull and Rayleigh distributions – measurement of wind – wind resource assessment – site selection – wind maps – estimation of energy yield – basic components of a wind energy conversion system (WECS).

UNIT-II: AERODYNAMICS OF WIND TURBINES (9 Periods)

Principles of aerodynamics – lift and drag – types of wind turbines – horizontal and vertical axis turbines – power coefficient, Betz limit – performance characteristics – tip speed ratio – torque and power curves – blade element theory – momentum theory – aerodynamic design considerations.

UNIT-III: WIND TURBINE COMPONENTS AND CONTROL SYSTEMS (9 Periods)

Main components: rotor, hub, gearbox, generator, yaw and pitch mechanisms, tower, and foundation – power transmission systems – electrical systems and controls – power regulation: stall, pitch, and yaw control – braking systems – safety mechanisms – condition monitoring and maintenance.

UNIT-IV: WIND ENERGY CONVERSION AND INTEGRATION (9 Periods)

Wind turbine generators – Squirrel cage induction generator (SCIG), Doubly fed induction generator (DFIG), and permanent magnet synchronous generator (PMSG) – power electronics and converters – grid integration issues – reactive power compensation – hybrid systems (wind–solar–diesel) – storage and reliability aspects – small wind systems – offshore wind energy systems.

UNIT-V: WIND FARM DESIGN, ECONOMICS AND ENVIRONMENTAL ASPECTS (9 Periods)

Wind farm layout design – spacing and siting considerations – wake effects – system performance prediction – operation and maintenance – cost components – economic analysis: payback period, NPV, IRR – government policies and incentives – environmental and social impacts – recent trends and case studies.

Total Periods: 45

Text Books:

- T1. Wind Energy Explained: On Land and Offshore, J.F. Manwell, E. Branlard, J.G. McGowan, B. Ram, John Wiley & Sons (Wiley-Blackwell), 2024, Third Edition.

- T2. Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, David Spera, ASME Press, 2009, Second Edition.
- T3. Wind and Solar Power Systems: Design, Analysis and Operation, Mukund R. Patel, Omid Beik, CRC Press (Taylor & Francis Group), 2021, Third Edition.

Reference Books:

- R1. Wind Energy Systems, Gary L. Johnson, Prentice Hall, 1998, Second Edition.
- R2. Wind Turbines: Fundamentals, Technologies, Application, Economics, Erich Hau, Sönke Siegfriedsen, Springer, 2025, Fourth Edition.
- R3. Renewable Energy in Power Systems, L.L. Freris, D.G. Infield, John Wiley & Sons, 2020, Second Edition.

Web Resources:

1. <https://alison.com/course/introduction-to-wind-energy>
2. <https://www.coursera.org/learn/wind-energy>
3. <https://www.udemy.com/course/introduction-to-wind-energy-systems>

2599202	M.Tech., II-SEMESTER COMUTATIONAL FLUID DYNAMICS (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: HEAT TRANSFER

Course Outcomes:

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

- CO1.** Apply the governing equations of fluid motion and understand their physical significance.
- CO2.** Formulate and discretize fluid flow problems using finite difference and finite volume methods.
- CO3.** Develop and implement numerical schemes to solve laminar and turbulent flow problems.
- CO4.** Analyze stability, consistency, and convergence of numerical solutions.
- CO5.** Simulate practical fluid flow and heat transfer problems using computational techniques and Interpret results effectively.

SYLLABUS:

UNIT–I: INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS: (9 Periods)

Governing equations of fluid flow and heat transfer – continuity, momentum, and energy equations – physical significance – classification of partial differential equations – mathematical behavior and boundary conditions – overview of CFD applications.

UNIT–II: DISCRETIZATION METHODS: (9 Periods)

Finite difference, finite volume and finite element methods – integral and differential formulations – grid generation and types of grids – discretization of 1D and 2D steady heat conduction equations – boundary conditions and their implementation – introduction to error analysis.

UNIT–III: SOLUTION OF DISCRETIZED EQUATIONS: (9 Periods)

Direct and iterative methods – Gauss elimination, Gauss–Seidel, TDMA, and SOR methods – convergence criteria – stability and consistency – treatment of source terms – implementation of boundary conditions – validation and verification of numerical solutions.

UNIT–IV: FLOW FIELD ANALYSIS: (9 Periods)

Discretization of convection–diffusion equation – upwind, central difference and hybrid schemes – pressure-velocity coupling algorithms: SIMPLE, SIMPLER, and PISO – solution of Navier–Stokes equations – introduction to turbulence models ($k-\epsilon$, $k-\omega$) and their applications.

UNIT–V: CFD APPLICATIONS AND CASE STUDIES: (9 Periods)

Simulation of laminar and turbulent flows – internal and external flow problems – flow over a flat plate, flow through a pipe, and flow past a cylinder – heat transfer in forced convection – introduction to commercial CFD software (ANSYS Fluent, Open FOAM) – result interpretation and post-processing.

Total Periods: 45

Text Books:

- T1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H.K. Versteeg and W. Malalasekera, Pearson Education, 2017, Third Edition.
- T2. Computational Fluid Dynamics: The Basics with Applications, John D. Anderson Jr., McGraw- Hill Education, 2018, Third Edition.
- T3. Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar, Hemisphere Publishing Corporation / Taylor & Francis, 2019, Fourth Edition.

Reference Books:

- R1. Computational Fluid Flow and Heat Transfer, K. Muralidhar and T. Sundararajan, Narosa Publishing House, 2013, Second Edition.
- R2. Computational Fluid Dynamics: A Practical Approach, Jiyuan Tu, Guan Heng Yeoh and Chaoqun Liu, Butterworth-Heinemann (Elsevier), 2012, Second Edition.

Web Resources:

1. https://www.cfd-online.com/Wiki/Main_Page
2. <https://www.grc.nasa.gov/www/k-12/airplane/cfd.html>
3. <https://ocw.mit.edu/courses/16-90-computational-methods-in-aerospace-engineering-spring-2014/>

2599203	M.Tech., II-SEMESTER SOLAR REFRIGERATION AND AIR CONDITIONING (PROGRAM ELECTIVE-III) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: SOLAR ENERGY TECHNOLOGY

Course Outcomes:

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

- CO1.** Understand the fundamentals of solar vapor compression and vapor absorption systems.
- CO2.** Analyze the design and working principles of desiccant, adsorption, and absorption refrigeration systems.
- CO3.** Evaluate the performance and thermodynamics of solar-based cooling systems.
- CO4.** Design suitable solar cooling systems for specific industrial and residential applications.
- CO5.** Assess the techno-economic feasibility and potential of solar refrigeration and air-conditioning systems.

SYLLABUS:

UNIT-I: INTRODUCTION TO SOLAR REFRIGERATION AND AIR CONDITIONING

(9 Periods)

Basics of refrigeration and air conditioning – comfort zones – potential and scope of solar cooling and heating – fundamentals of conventional vapor compression and vapor absorption systems – role of solar energy in cooling applications – comparison of solar and conventional systems.

UNIT-II: SOLAR COOLING TECHNOLOGIES

(9 Periods)

Solar electrical cooling – solar thermal cooling – open cycles: liquid and solid desiccant systems – closed cycles: absorption, adsorption, and solar radiation cooling – thermo- mechanical systems – steam ejector cycle – solar combined power/cooling systems – performance evaluation and design aspects.

UNIT-III: DESICCANT AIR-CONDITIONING SYSTEMS

(9 Periods)

Desiccant materials – classification and properties – adsorption and regeneration processes – Adsorption rate, regeneration rate, and influencing factors – heating/humidification and cooling/dehumidification processes – desiccant dehumidifiers: bed, wheel, and coated heat exchangers – solar-powered desiccant air-conditioning systems.

UNIT-IV: ADSORPTION AND ABSORPTION REFRIGERATION SYSTEMS

(9 Periods)

Adsorption refrigeration systems: principles, thermodynamics of adsorption cycles – basic, heat recovery, mass recovery, thermal wave, and convective thermal wave cycles – intermittent adsorption systems (silica gel–water, zeolite–water, and activated carbon– methanol/ammonia).

Absorption systems: aqua–ammonia and LiBr–water systems – h–x diagram – absorption cycle operation, COP, and performance – single-effect, half-effect, double-effect, diffusion absorption, and hybrid solar-assisted cooling systems.

UNIT-V: ADVANCED SOLAR COOLING SYSTEMS AND ECONOMIC

(9 Periods)

Types of solar cooling systems – solar collectors and storage systems – open-cycle absorption/desorption systems – advanced and hybrid solar cooling technologies – refrigerant storage for solar absorption systems – solar thermoelectric refrigeration and air conditioning – system integration with renewable sources – economics and feasibility of solar cooling systems.

Total Periods: 45

Text Books:

- T1. Solar Air Conditioning and Refrigeration, J. C. McVeigh and A. A. M. Sayigh, Pergamon / Elsevier, 2022, Second Edition.
- T2. Refrigeration and Air Conditioning, M. Prasad, New Age International Publishers, 2018, First Edition.
- T3. The Solar Cooling Design Guide: Case Studies of Successful Solar Air Conditioning Design, Daniel Mugnier, Daniel Neyer, Stephen D. White (Eds.), Wiley / Ernst & Sohn, 2017, First Edition.

Reference Books:

- R1. Advances in Solar Heating and Cooling, Ruzhu Wang and Tianshu Ge (Eds.), Woodhead Publishing (Elsevier), 2016, First Edition.
- R2. Modern Refrigeration and Air Conditioning, Andrew D. Althouse, Carl H. Turnquist, Alfred F. Bracciano, Daniel C. Bracciano, Gloria M. Bracciano, Goodheart-Willcox Publisher, 2023, Twenty Second Edition.

Web Resources:

1. <https://www.iea-shc.org>
2. <https://www.ashrae.org>

2599204	M.Tech., II-SEMESTER ENERGY RECOVERY AND MANAGEMENT SYSTEMS (PROGRAM ELECTIVE-III) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: ENERGY AUDIT AND MANAGEMENT

Course Outcomes:

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

- CO1.** Understand the sources and classifications of waste heat and its impact on energy conservation.
- CO2.** Evaluate various waste heat recovery systems and technologies used in industries.
- CO3.** Design appropriate waste heat recovery equipment for thermal and mechanical systems.
- CO4.** Analyze the performance and efficiency of waste heat recovery devices.
- CO5.** Apply waste heat recovery and energy conservation techniques for sustainable and economical operation of industrial systems.

SYLLABUS:

UNIT-I: INTRODUCTION TO ENERGY CONSERVATION AND WASTE HEAT RECOVERY (9 Periods)

Introduction to energy scenario – importance of energy conservation – classification of energy losses – concept of waste heat – sources and quality of waste heat in industries – temperature levels of waste heat – potential for waste heat recovery – advantages and limitations of waste heat recovery – energy auditing and management principles.

UNIT-II: PRINCIPLES AND METHODS OF WASTE HEAT RECOVERY (9 Periods)

Fundamentals of heat recovery – direct and indirect recovery methods – selection criteria for waste heat recovery systems – classification: recuperates, regenerators, heat exchangers – heat pipe heat exchangers – run-around coils – economizers – rotary regenerators – design considerations.

UNIT-III: HEAT RECOVERY EQUIPMENT AND SYSTEM DESIGN (9 Periods)

Construction, working, and performance analysis of heat recovery devices – shell and tube heat exchangers – plate heat exchangers – waste heat boilers – air preheaters – recuperates for furnaces – design aspects and material considerations – estimation of heat recovery potential and energy savings.

UNIT-IV: THERMAL ENERGY STORAGE AND COMBINED SYSTEM (9 Periods)

Integration of waste heat recovery with thermal energy storage – phase change materials – sensible and latent heat storage – thermochemical storage – combined heat and power (CHP) systems – cogeneration principles and performance analysis – regeneration – applications in process industries and power plants.

UNIT-V: ADVANCED WASTE HEAT UTILIZATION TECHNOLOGIES

(9 Periods)

Organic Rankine cycle (ORC) systems – thermoelectric generators – heat pumps – absorption refrigeration systems utilizing waste heat – heat recovery from IC engines, kilns, and furnaces – case studies of industrial waste heat recovery – environmental and economic benefits – recent trends and technologies.

Total Periods: 45

Text Books:

- T1. Waste Heat Recovery Systems: Principles and Applications, Charles H. Rathore and Dr. S. K. Kapuno, CRC Press, 2020, First Edition.

- T2. A Course in Heat Power Engineering, S.C. Arora and S. Domkundwar, Dhanpat Rai & Co., 2019, Sixth Edition.
- T3. Waste Heat Recovery Systems: Design and Applications, D.A. Reay and A. Reay, E & F.N. Spon Ltd., 2019, Fourth Edition.

Reference Books:

- R1. Compact Heat Exchangers, Kays W.M. and London A.L., McGraw Hill, 2018, Fifth Edition.
- R2. Energy: Management, Supply and Conservation, Beggs C., Routledge, 2017, Second Edition.

Web Resources:

1. https://www.energystar.gov/industrial_plants/waste_heat_recovery
2. https://onlinecourses.nptel.ac.in/noc25_me114/preview

2599205	M.Tech., II-SEMESTER ENERGY EFFICIENCY AND RENEWABLE ENERGY SYSTEMS (PROGRAM ELECTIVE-III) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: INTRODUCTION TO RENEWABLE ENERGY SYSTEMS

Course Outcomes:

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

- CO1.** Understand the fundamentals and importance of energy efficiency and renewable energy projects.
- CO2.** Evaluate various renewable energy resources and technologies suitable for project development.
- CO3.** Apply methods for conducting feasibility, techno-economic, and environmental analyses of energy projects.
- CO4.** Develop project proposals with financial, policy, and regulatory considerations.
- CO5.** Design and manage energy efficiency and renewable energy projects for sustainable implementation.

SYLLABUS:

UNIT-I: ENERGY EFFICIENCY AND RENEWABLE ENERGY PROJECTS

(9 Periods)

Global and national energy scenarios – energy demand and supply issues – importance of renewable energy and energy efficiency – types of renewable energy resources – project identification and classification – overview of project development cycle – energy policy framework and institutional support in India.

UNIT-II: ENERGY AUDIT AND CONSERVATION TECHNIQUES

(9 Periods)

Energy audit – types, methodology, and instruments – process and utility audits – data collection and analysis – energy conservation opportunities in electrical, thermal, and utility systems – energy performance indicators – benchmarking – best practices in industries – role of energy managers and auditors.

UNIT-III: TECHNO-ECONOMIC ANALYSIS OF RENEWABLE ENERGY PROJECTS

(9 Periods)

Project feasibility studies – technical, economic, financial, and environmental analysis – cost-benefit evaluation – life-cycle cost analysis – net present value (NPV), internal rate of return (IRR), and payback period calculations – sensitivity and risk analysis – carbon credit evaluation and Clean Development Mechanism (CDM).

UNIT-IV: PROJECT DESIGN AND IMPLEMENTATION STRATEGIES

(9 Periods)

Steps in project development – resource assessment and technology selection – site selection and system design – project scheduling and implementation – project management techniques – monitoring and evaluation – stakeholder engagement – documentation for government and international funding agencies.

UNIT-V: POLICY, REGULATION, AND CASE STUDIES IN ENERGY PROJECTS

(9 Periods)

National and international policies promoting renewable energy and efficiency – regulatory frameworks, incentives, and financing mechanisms – energy service companies (ESCOs) and

performance contracting – Public–Private Partnership (PPP) models – case studies on solar, wind, biomass, small hydro, and waste-to-energy projects – success factors and challenges.

Total Periods: 45

Text Books:

- T1. Renewable Energy Resources, John Twidell, Tony Weir, Routledge (Taylor & Francis Group), 2015, Third Edition
- T2. Energy Management Handbook, Wayne C. Turner, Steve Doty, Fairmont Press / CRC Press, 2016, Ninth Edition.
- T3. Renewable and Efficient Electric Power Systems, Gilbert M. Masters, John Wiley & Sons, 2013, Second Edition

Reference Books:

- R1. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2012, Third Edition
- R2. Energy Efficiency and Renewable Energy Handbook, Frank Kreith, D. Yogi Goswami, CRC Press, 2007, First edition
- R3. Handbook of Energy Audits, Albert Thumann, Terry Niehus, William J. Younger, Fairmont Press / CRC Press, 2012, Ninth Edition

Web Resources:

1. <https://www.irena.org>
2. <https://www.nrel.gov>
3. https://onlinecourses.nptel.ac.in/noc22_ge08/preview

2599206	M.Tech., II-SEMESTER	L	T	P	C
	HYDROGEN PRODUCTION, STORAGE, AND FUEL CELL APPLICATIONS (PROGRAM ELECTIVE-IV) (RENEWABLE ENERGY)	3	0	0	3

PRE-REQUISITES: HYDROGEN AND FUEL CELL TECHNOLOGIES

Course Outcomes:

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

- CO1.** Understand the fundamentals, production methods, and properties of hydrogen as an energy Carrier.
- CO2.** Analyze various hydrogen storage and transportation techniques for industrial and mobile applications.
- CO3.** Understand the working principles and characteristics of different fuel cell systems.
- CO4.** Evaluate the performance, design, and operation of hydrogen-based and fuel cell power systems.
- CO5.** Apply hydrogen and fuel cell technologies for sustainable energy generation and environmental conservation.

SYLLABUS:

UNIT-I: INTRODUCTION TO HYDROGEN ENERGY (9 Periods)

Hydrogen as an energy carrier – properties, advantages, and limitations – global and national hydrogen scenario – classification and applications of hydrogen – comparison with conventional fuels – hydrogen energy systems and their role in renewable energy integration – safety considerations and handling.

UNIT-II: HYDROGEN PRODUCTION TECHNOLOGIES (9 Periods)

Hydrogen production from fossil fuels: steam reforming, partial oxidation, and coal gasification – water splitting methods: electrolysis, thermochemical, photochemical, photo electrochemical, and biological processes – hybrid and renewable-based hydrogen production – efficiency, cost, and environmental aspects of various production methods.

UNIT-III: HYDROGEN STORAGE AND TRANSPORTATION (9 Periods)

Hydrogen storage options – compressed gas, liquid hydrogen, cryogenic storage – metal hydrides, chemical hydrides, and carbon-based materials – storage design considerations – hydrogen transportation: pipelines, cylinders, and cryogenic tankers – distribution infrastructure and refueling systems.

UNIT-IV: FUEL CELL FUNDAMENTALS AND TYPES (9 Periods)

Fuel cell principle and operation – components: electrodes, electrolyte, catalyst, and bipolar plates – polarization characteristics and performance – classification of fuel cells: alkaline fuel cell (AFC), proton exchange membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC) – comparative analysis and applications.

UNIT-V: FUEL CELL SYSTEM DESIGN AND APPLICATIONS (9 Periods)

Fuel cell stack design – system integration – hybrid fuel cell systems – hydrogen-powered vehicles – portable and stationary power applications – environmental impacts and efficiency analysis – case studies on hydrogen and fuel cell projects – challenges and future prospects of hydrogen economy.

Total Periods: 45

Text Books:

- T1. Hydrogen Energy and Fuel Cells: Science and Applications, Zhen Zhang, Springer Singapore, 2026, First Edition.
- T2. Hydrogen Fuel Cells, Shengjie Peng, Springer Singapore, 2024, First Edition.
- T3. Hydrogen Utilization in Fuel Cells, Mohammad Reza Rahimpour, Mohammad Amin Makarem & Parvin Kiani, CRC Press/Taylor & Francis, **2025**, First Edition.

Reference Books:

- R1. Fuel Cell Fundamentals and Applications, Yinshi Li, Springer Singapore, 2025, First Edition.
- R2. Next-Generation Hydrogen Economy: Production, Storage, and Fuel Cell Technologies, Peeyush Phogat, Shreya Sharma & Satyam Rawat, Wiley-VCH, 2025, First Edition.
- R3. Hydrogen and Fuel Cells: Innovations and Challenges, Hanqing Yang, Jiajia Yang & Zening Li, MDPI Books, 2025, First Edition.

Web Resources:

1. <https://www.iea.org/energy-system/hydrogen>
2. https://onlinecourses.nptel.ac.in/noc23_me74/preview
3. <https://hydrogeneurope.eu>

2599207	M.Tech., II-SEMESTER BIO ENERGY (PROGRAM ELECTIVE-IV) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: NIL

Course Outcomes:

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

- CO1.** Understand the fundamental principles and sources of bioenergy.
- CO2.** Analyze various biomass conversion technologies for energy production.
- CO3.** Design and evaluate biogas generation systems and their applications.
- CO4.** Assess the performance of biofuels and their environmental impacts.
- CO5.** Apply bioenergy technologies for sustainable and decentralized energy generation.

SYLLABUS:

UNIT–I: INTRODUCTION TO BIO ENERGY (9 Periods)

Introduction – definition, scope and importance of bioenergy – energy from biomass and its role in renewable energy mix – classification and sources of biomass – characteristics of biomass – comparison with conventional fuels – biomass availability and assessment – environmental and socio-economic benefits.

UNIT–II: BIOMASS CONVERSION TECHNOLOGIES (9 Periods)

Biochemical, thermochemical, and physicochemical conversion routes – combustion, gasification, pyrolysis, liquefaction – types of gasifiers and their performance – fixed bed and fluidized bed gasifiers – bio-oil production and up gradation – syngas generation and applications – efficiency and emission aspects.

UNIT–III: BIOGAS TECHNOLOGY (9 Periods)

Biogas: composition, properties, and factors affecting biogas production – anaerobic digestion process and microbiology – types of biogas plants: fixed dome, floating drum, and plug flow – design, operation, and maintenance – biogas purification and bottling – applications of biogas in domestic, transport, and power generation sectors – case studies on rural biogas plants.

UNIT–IV: LIQUID BIOFUELS (9 Periods)

Liquid biofuels: classification, production, and utilization – ethanol and methanol production from biomass – trans esterification process for biodiesel production – feed stocks for biodiesel – properties and comparison with diesel – blending and performance analysis – environmental impacts and emission characteristics – bio-refineries and integrated biofuel systems.

UNIT–V: ADVANCED BIOENERGY SYSTEMS AND APPLICATIONS (9 Periods)

Algae-based biofuel production – bio hydrogen generation – bioelectricity and microbial fuel cells – combined heat and power (CHP) systems from biomass – waste-to-energy technologies – economics and life cycle assessment of bioenergy projects – government policies and programs on bioenergy development in India – future prospects and challenges.

Total Periods: 45

Text Books:

- T1. Bioenergy: Principles and Applications, Yebo Li and Samir Kumar Khanal, John Wiley & Sons, 2016, First Edition.
- T2. Bioenergy Research: Basic and Advanced Concepts, Manish Srivastava, Neha Srivastava and Rajeev Singh, Springer Singapore, 2021, First Edition.
- T3. Renewable Energy Development: Technology, Material and Sustainability, Santosh Kumar and Vivek Kumar Singh, Springer Nature, 2025, First Edition.

Reference Books:

- R1. Bioenergy: Impacts on Environment and Economy, Praveen Kumar Ramanujam, Binod Parameswaran, B. Bharathiraja and A. Magesh, Springer Singapore, 2023, First Edition.
- R2. Sustainable Energy and Fuels: Materials, Processing Methods, and Development, Piyush Verma, Ahmed Boubakeur, Leila Mokhnache and Balwinder Raj, CRC Press, 2024, First Edition.
- R3. Bioenergy and Biochemical Processing Technologies: Recent Advances and Future Demands, Augustine O. Ayeni, Samuel Eshorame Sanni and Solomon U. Oranusi (Eds.), Springer Cham, 2022, First Edition.

Web Resources:

1. <https://www.ieabioenergy.com>
2. <https://www.nrel.gov/bioenergy/>
3. <https://www.fao.org/energy/bioenergy/en/>
4. https://onlinecourses.nptel.ac.in/noc23_ce89/preview

2599208	M.Tech., II-SEMESTER RENEWABLE ENERGY PROCESS MODELING AND ANALYSIS (PROGRAM ELECTIVE-IV) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: PROCESS MODELING AND SIMULATION IN RENEWABLE ENERGY SYSTEMS COMPUTATIONAL METHODS

Course Outcomes:

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

- CO1.** Understand the fundamentals of process modeling and simulation techniques in renewable Energy systems.
- CO2.** Develop mathematical models for various renewable energy conversion processes.
- CO3.** Apply simulation tools to analyze performance and optimize system parameters.
- CO4.** Evaluate hybrid and integrated renewable energy systems using simulation approaches.
- CO5.** Design and simulate renewable energy systems for real-world applications.

SYLLABUS:

UNIT-I: INTRODUCTION TO MODELING AND SIMULATION (9 Periods)

Introduction – need and significance of modeling and simulation – types of models: physical, mathematical, and empirical – modeling approaches for renewable energy systems – formulation of system equations – dynamic and steady-state modeling – introduction to simulation tools such as MATLAB/Simulink, Aspen Plus, TRNSYS, and HOMER – model validation and verification techniques.

UNIT-II: MODELING OF SOLAR ENERGY SYSTEMS (9 Periods)

Modeling of solar radiation – prediction models – modeling of flat plate and concentrating collectors – solar photovoltaic system modeling – I-V and P-V characteristics – maximum power point tracking (MPPT) modeling – solar thermal energy system simulation – performance analysis using TRNSYS or MATLAB – case studies on solar water heating and PV-based microgrid.

UNIT-III: MODELING OF WIND AND BIOENERGY SYSTEMS (9 Periods)

Wind resource assessment and modeling – wind turbine aerodynamics – power curve modeling – wind farm simulation and layout optimization – modeling of biogas and biomass gasification systems – energy balance equations – simulation of bioenergy power generation and cogeneration systems – integration of wind-bio hybrid systems.

UNIT-IV: MODELING OF HYDROGEN, FUEL CELL, AND HYBRID SYSTEMS (9 Periods)

Mathematical modeling of electrolyzers and fuel cells – performance and efficiency modeling – modeling of hydrogen storage systems – integration with solar and wind systems – hybrid renewable systems modeling (PV-Wind-Fuel cell) – load demand analysis – optimization of hybrid system configuration using HOMER or MATLAB – sensitivity analysis and techno-economic evaluation.

UNIT-V: OPTIMIZATION AND CASE STUDIES (9 Periods)

Optimization techniques in renewable energy modeling – linear and nonlinear programming – genetic algorithms, particle swarm optimization, and artificial neural networks for model improvement – simulation-based performance prediction and economic assessment – case studies on hybrid energy systems, smart grids, and distributed generation – recent advancements in digital twins and AI-based renewable system modeling.

Total Periods: 45

Text Books:

- T1.** D. Yogi Goswami, Frank Kreith, Energy Conversion, CRC Press, 2008, First Edition.
- T2.** Ramesh K. Shah, D. P. Sekulic, Fundamentals of Heat Exchanger Design and Simulation, John Wiley & Sons, 2015, Second Edition.
- T3.** Soteris A. Kalogirou, Solar Energy Engineering: Processes and Systems, Academic Press, 2014, Second Edition.

Reference Books:

- R1.** Soteris A. Kalogirou, Applied Energy: Simulation, Modeling, and Control in Renewable Energy Systems, Elsevier, 2020, First Edition.
- R2.** J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, Wiley, 2013, Fourth Edition.
- R3.** Ibrahim Dincer and C. A. Bicer, Modeling and Optimization of Renewable Energy Systems, Elsevier, 2021, First Edition.

Web Resources:

- 1. <https://nptel.ac.in/courses/112107298>
- 2. https://onlinecourses.nptel.ac.in/noc23_me69/preview
- 3. <https://nptel.ac.in/courses/112106287>
- 4. https://onlinecourses.nptel.ac.in/noc24_me47/preview

2599251	M.Tech., II-SEMESTER WIND ENERGY LAB (RENEWABLE ENERGY)	L	T	P	C
		0	0	4	2

PRE-REQUISITES: NIL

Course Outcomes:

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

- CO1.** Measure and analyze wind energy parameters including wind speed, energy density, and velocity Profiles using laboratory instruments.
- CO2.** Understand the aerodynamic behavior of wind turbine blades and quantify lift, drag, and pressure Distribution under varying conditions.
- CO3.** Evaluate the effect of blade pitch, airfoil type, and wind velocity on the performance of a wind Turbine.
- CO4.** Able to apply appropriate Tools and Techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** Work as a team and communicate results in an effective way.
- CO6.** Make decisions as an individual or as team member to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

List of Experiments:

1. Determination of Average Wind Energy Density by using a Anemometer
2. Aerodynamic Pressure Distribution Study of a Wind Turbine Blade in a Wind Tunnel under Constant Velocity
3. Aerodynamic Force Study of a Wind Turbine Blade in a Wind Tunnel with varying Velocity
4. Aerodynamic Force Study of a Wind Turbine Blade with varying pitch
5. Velocity profiling of a Wind Turbine Blade and Calculation of Drag Coefficient
6. Study of Wind Generator Electrical Output Characteristics for Different Types of Airfoil Assemblies
7. Determination of Power Production in a Wind Turbine as a Function of Wind Speed
8. To study the Variation of Coefficient of Power with respect to Wind Speed for a Wind Turbine

TEXT BOOKS/LABORATORY MANUALS:

- T1.** Wind Turbines: Fundamentals, Technologies, Application, Economics, Erich Hau, Springer, 2013, Second Edition.
- T2.** Wind Energy Explained: Theory, Design and Application, Manwell, J. F., McGowan, J. G., and Rogers, A. L., John Wiley & Sons, 2010, Second Edition.
- T3.** Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, Spera, D. A., ASME Press, 2009, Second Edition.

Reference Books:

- R1.** Wind Energy Handbook, Burton, T., Jenkins, N., Sharpe, D., and Bossanyi, E., John Wiley & Sons, 2021, Third Edition.
- R2.** Renewable Energy in Power Systems, Freris, L. L., and Infield, D., John Wiley & Sons, 2008, Second Edition.

Web Resources:

1. <https://nptel.ac.in/courses/112107298>
2. https://onlinecourses.nptel.ac.in/noc23_me69/preview
3. <https://nptel.ac.in/courses/112106287>
4. https://onlinecourses.nptel.ac.in/noc24_me47/preview

2599252	M.Tech., II-SEMESTER CONTROL SYSTEMS AND SIMULATION LAB (RENEWABLE ENERGY)	L	T	P	C
		0	0	4	2

PRE-REQUISITES: NIL

Course Outcomes:

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

- CO1.** Understand and analyze the characteristics and working of synchros, DC machines, and magnetic amplifiers.
- CO2.** Determine the time and frequency response of second-order systems and evaluate the effect of P, PI, and PID controllers.
- CO3.** Design and implement lead and lag compensators in the frequency domain using MATLAB.
- CO4.** Able to apply appropriate Tools and Techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** Work as a team and communicate results in an effective way.
- CO6.** Make decisions as an individual or as team member to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

LIST OF EXPERIMENTS:

1. Characteristics of Synchros
2. Transfer Function of DC Machine
3. Characteristics of Magnetic Amplifiers
4. Time Response of Second Order System
5. Effect of P, PI and PID controller of a Second Order System
6. Lead and Lag Compensated Design in Frequency Domain using MATLAB
7. Linear System Analysis (Time Domain using MATLAB)
8. Linear System Analysis (Root Locus and Bode Plot of Linear Time Invariant Systems using MATLAB)
9. State Space Model for Classical Transfer Function using MATLAB

TEXT BOOKS/LABORATORY MANUALS:

- T1.** Automatic Control Systems, Benjamin C. Kuo and Farid Golnaraghi, John Wiley & Sons, 2017, Ninth Edition.
- T2.** Modern Control Engineering, Ogata, K., Prentice Hall, 2010, Fifth Edition.
- T3.** Control Systems Engineering, Norman S. Nise, John Wiley & Sons, 2015, Seventh Edition.

Reference Books:

- R1.** Katsuhiko Ogata, Discrete-Time Control Systems, Prentice Hall, 2002, Second Edition.
- R2.** Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson Education, 2022, Fourteenth Edition.

Web Resources:

1. <https://nptel.ac.in/courses/108105130>
2. <https://nptel.ac.in/courses/108105132>
3. https://onlinecourses.nptel.ac.in/noc24_ee37/preview
4. https://onlinecourses.nptel.ac.in/noc24_ee40/preview
5. Virtual Lab:<https://vlab.co.in/>

2552253	M.Tech., II-SEMESTER COMPREHENSIVE VIVA VOCE (POWER SYSTEMS)	L	T	P	C
		0	0	0	2

Pre-Requisites: All Courses

Course Outcomes:

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

- CO1.** Demonstrate comprehensive understanding of core concepts learned throughout the program.
- CO2.** Apply theoretical knowledge to analyze and solve discipline-specific problems.
- CO3.** Communicate technical ideas, concepts, and project outcomes clearly and effectively during oral examination.
- CO4.** Integrate knowledge from various subjects to justify solutions and decisions.
- CO5.** Exhibit critical thinking, professional ethics, and confidence while responding to technical and situational questions.

2598281	M.Tech., II-SEMESTER	L	T	P	C
	QUANTUM TECHNOLOGIES AND APPLICATIONS (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (MANDATORY COURSE-II)	2	0	0	2

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Demonstrate the basic principles and technological importance of quantum physics.
- CO2.** Explain the basic concepts of qubits, quantum states, entanglement, and differences between classical and quantum information systems..
- CO3.** Analyze the key challenges and requirements in developing stable and scalable quantum hardware systems.
- CO4.** Explain the basic concepts of quantum communication and computing, including QKD, quantum parallelism, and related challenges.
- CO5.** Demonstrate the major applications, industry developments, and future opportunities of quantum technologies along with their societal and practical challenges.

SYLLABUS:

UNIT-I: FOUNDATIONS OF QUANTUM THEORY AND TECHNOLOGIES (05 Periods)

Transition from classical to quantum physics. Key conceptual principles: Superposition, Entanglement, Uncertainty, Wave-particle duality. Quantum states and measurement; the role of the observer. Representative quantum systems: electrons, photons, atoms. Concept of quantization and discrete energy levels. Strategic relevance of quantum technologies.

Overview of major domains: Computing, Communication, Sensing. Global quantum initiatives: India's National Quantum Mission, EU Quantum Flagship, USA, China.

UNIT-II: CONCEPTUAL STRUCTURE OF QUANTUM INFORMATION (07 Periods)

Qubits: qualitative understanding using spin and polarization. Classical bits vs quantum bits: distinctions and implications. Quantum systems (non-engineering perspective): trapped ions, superconducting qubits, photonics. Coherence and decoherence mechanisms. Abstract notions: quantum states, measurement operators, Hilbert space—interpretation without mathematics. Entanglement and non-locality as foundational resources. Quantum vs classical information principles; philosophical considerations.

UNIT-III: BUILDING A QUANTUM COMPUTER – CHALLENGES AND REQUIREMENTS (06 Periods)

Conceptual prerequisites for functional quantum hardware. Fragility of quantum states: decoherence, noise, stability issues. Requirements: isolation, error resilience, scalability, control. Why maintaining entanglement is difficult; theoretical necessity of quantum error correction. Comparative overview of hardware platforms (superconducting circuits, trapped ions, photonics). Current progress vs scientific constraints; conceptual view of quantum software's role.

UNIT-IV: QUANTUM COMMUNICATION AND COMPUTING (06 Periods)

Quantum vs classical communication paradigms. Essentials of Quantum Key Distribution (QKD) and its security rationale. Entanglement-enabled communication protocols. Concept of the Quantum Internet and secure global networking. Introduction to quantum computing and quantum

parallelism.

Conceptual comparison of classical and quantum gate operations. Challenges: decoherence, noise, and the necessity of error correction frameworks.

UNIT-V: APPLICATIONS, INDUSTRY, AND FUTURE DIRECTIONS (06 Periods)

Application domains: Healthcare and drug discovery, Material science and chemistry, Optimization and logistics, Quantum sensing and precision timing. Case studies: IBM, Google, Microsoft, PsiQuantum. Ethical, societal, and policy considerations. Barriers to adoption: cost, skilled workforce, standards. Emerging research and career landscapes; India's strategic opportunity in the global quantum ecosystem.

Total Periods: 30

Textbooks:

- T1. Quantum Computation and Quantum Information, Nielsen & Chuang, Cambridge University Press, 2010.
- T2. Quantum Computing: A Gentle Introduction, Rieffel & Polak, MIT Press, 2011.
- T3. Quantum Computing for Everyone, Chris Bernhardt, MIT Press, 2019.

Reference Books:

- R1. Quantum Computing Explained, David McMahon, Wiley, 2008.
- R2. An Introduction to Quantum Computing, Kaye, Laflamme, Mosca, OUP, 2007.
- R3. Quantum Computing Since Democritus, Scott Aaronson, CUP, 2013.
- R4. Quantum Mechanics: The Theoretical Minimum, Susskind & Friedman, Basic Books, 2014.
- R5. Quantum Enigma, Rosenblum & Kuttner, OUP, 2011.
- R6. Principles of Quantum Computation and Information, Benenti et al., World Scientific, 2004.
- R7. DST India and MeitY: Official Quantum Mission Reports, 2020 onwards.
- R8. Quantum Flagship EU: Roadmaps and Strategy Documents.

Online Learning Resources

1. IBM Quantum Experience & Qiskit Textbook Coursera – Quantum Mechanics and Quantum Computation (UC Berkeley) edX – Quantum Internet & Quantum Computers
2. YouTube – Quantum Computing for the Determined (Michael Nielsen)

25HS201	M.Tech., II-SEMESTER PEDAGOGY STUDIES	L	T	P	C
	(Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE-II)	2	0	0	0

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Apply pedagogy, learning theories, and technology to design learner-centered education.
- CO2.** Design and implement effective lesson plans and curriculum using appropriate teaching strategies and technology tools to enhance the teaching–learning process.
- CO3.** Analyze and apply instructional design models, emerging e-learning trends, and ICT tools to design and implement effective technology-integrated teaching–learning systems.
- CO4.** Apply pedagogical analysis and appropriate assessment methods, including technology-based tools and reflective practices, to improve teaching–learning effectiveness.
- CO5.** Apply pedagogical analysis and appropriate assessment methods, including technology-based tools and reflective practices, to improve teaching–learning effectiveness.

SYLLABUS:

UNIT-I: FOUNDATIONS OF PEDAGOGY (05 Periods)

Introduction to pedagogy and its importance in education - Historical and philosophical foundations of pedagogy - Theories of learning and teaching (behaviorist, cognitive, constructivist) - Role of pedagogy in shaping educational practices - Role of technology in modern pedagogy (ICT, e-learning, blended learning)

UNIT-II: TEACHING-LEARNING PROCESSES (06 Periods)

Understanding the teaching-learning process - Lesson planning and curriculum design - Strategies for effective teaching and learning (expository, collaborative, experiential) - Use of technology to enhance teaching-learning processes (multimedia, simulations, gamification)

UNIT-III: TECHNOLOGY INTEGRATION IN EDUCATION (07 Periods)

Educational technology and system design - Instructional design models (ADDIE, ASSURE, Dick and Carey Model) - Emerging trends in e-learning (social learning, MOOCs, mobile learning) - ICT tools for teaching and learning (Learning Management Systems, online resources)

UNIT-IV: PEDAGOGY AND ASSESSMENT (06 Periods)

Pedagogy, pedagogical analysis, and assessment - Types of assessment (placement, formative, diagnostic, summative) - Technology-based assessment tools (online quizzes, polls, discussions) - Rubrics for self and peer evaluation- Reflective Practices

UNIT-V: CONTEMPORARY ISSUES AND TRENDS (06 Periods)

Inclusive education and technology (assistive technology, accessibility) - Change management and innovation in education - Quality assurance and evaluation in education (TQM, Six Sigma) - Future trends in pedagogy and technology (AI, AR, VR in education) - Personalized learning and adaptive teaching

Total Periods: 30

Text Books:

- T1. Essays on Pedagogy, Alexander, R. J., Routledge, 2008.
- T2. The Wisdom of Practice: Essays on Teaching, Learning, and Learning to Teach, Shulman, L. S., Jossey-Bass, 2004

Reference Books:

- R1. Teaching for the Future: Effective Teacher Education and Pedagogical Practices. OECD Publishing., 2021
- R2. System Change in Education: Sustainability and Impact, Fullan, M., & Edwards, M, Routledge, 2022.
- R3. Great Teaching Toolkit: Evidence Review, Coe, R., Rauch, C., Kime, S., & Singleton, D., Evidence Based Education., 2020
- R4. The Struggle for the Soul of Teacher Education, Zeichner, K. M., Routledge, 2024
- R5. UNESCO. Global Education Monitoring Report: Pedagogy, Teachers and Learning. UNESCO Publishing, 2024
- R6. Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement, Hattie, J., Routledge., 2009
- R7. Teacher Education Around the World: What Can We Learn from International Practice?, Darling-Hammond, L. , Routledge, 2007

Online Resources:

1. UNESCO Education Resources – <https://www.unesco.org/education>
2. OECD Education and Skills – <https://www.oecd.org/education>
3. ERIC (Education Resources Information Center) – <https://eric.ed.gov> (peer-reviewed papers, reports).
4. World Bank Education – <https://www.worldbank.org/en/topic/education> (research reports on teacher development in developing countries).
5. NPTEL/SWAYAM MOOCs – Teacher education and pedagogy-focused courses.
6. Google Scholar Alerts – set alerts for "pedagogical practices", "teacher education", "curriculum research" for the latest academic papers.

25HS202	M.Tech., II-SEMESTER	L	T	P	C
	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE-II)	2	0	0	0

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Practice self-awareness and personal effectiveness by analyzing strengths, weaknesses, opportunities, and challenges (SWOC), setting SMART goals, and practicing reflection, journaling, and self-care strategies.
- CO2.** Evince emotional intelligence by developing self-awareness, self-regulation, motivation, communication, interpersonal, and conflict-resolution skills for personal and professional effectiveness.
- CO3.** Exhibit a positive mindset, resilience, and emotional well-being by cultivating growth-oriented thinking, gratitude, mindfulness, and strategies to overcome negative thoughts and behaviors.
- CO4.** Enhance personal and professional effectiveness by developing verbal, non-verbal, and presentation skills, while building confidence and competence in public speaking.
- CO5.** Demonstrate leadership capabilities by understanding styles and qualities, enhancing teamwork, collaboration, and problem-solving skills for effective team management.

SYLLABUS:

UNIT-I: SELF-AWARENESS AND PERSONAL GROWTH (06 Periods)

Understanding personality and its development- Identifying strengths, weaknesses, opportunities, and challenges (SWOC analysis)- Setting personal and professional goals- Practicing Self-Reflection and Journaling

(Activities: Personality assessments, self reflection exercises, group discussions, SWOC analysis worksheet, Action Plan, SMART goal activities, Reflective journaling, Self-care Planning)

UNIT-II: EMOTIONAL INTELLIGENCE AND INTERPERSONAL SKILLS (06 Periods)

Understanding emotional intelligence and its importance - Developing self-awareness, self-regulation, and motivation - Building effective communication and interpersonal skills - Conflict resolution and negotiation strategies.

(Activities: Emotional Intelligence Quiz, Self-Reflection exercises, feedback sessions, mindfulness exercises, Positive self-talk, Active Listening exercises, conflict-resolution Role-play, Case studies & Group activities)

UNIT-III: POSITIVE THINKING AND ATTITUDE (06 Periods)

Understanding the power of positive thinking- Developing a growth mindset and resilience - Practicing gratitude and mindfulness- Overcoming negative thoughts and behaviors

(Activities on positive thinking, growth mindset, mindfulness and self-care plan for overcoming negative thoughts)

UNIT-IV: EFFECTIVE COMMUNICATION AND PRESENTATION SKILLS (06 Periods)

Understanding the importance of effective communication- Developing verbal and non-verbal communication skills- Preparing and delivering effective presentations- Building confidence and public speaking skills

(Activities: Group discussions, Case studies, Role-Play, Non-verbal communication exercises, Practice presentations, Peer feedback, Public speaking exercises, Storytelling, Debates)

UNIT-V: LEADERSHIP AND TEAMWORK (06 Periods)

Understanding leadership styles and qualities - Developing leadership skills and qualities- Building effective teams and teamwork strategies- Practicing collaboration and problem-solving

(Activities: Case studies, Group discussions, Debates, Leadership role-playing, team building activities, Group projects, Collaborative problem-solving exercises, feedback sessions)

Total Periods: 30

Text Books:

- T1. Daniel Goleman, Emotional Intelligence: Why It Can Matter More Than IQ, Bantam Books, 2017.
- T2. Stephen R. Covey, The 7 Habits of Highly Effective People, Simon & Schuster, 2020

Reference Books:

- R1. Dale Carnegie, How to Win Friends and Influence People, Simon & Schuster, 2020.
- R2. Brian Tracy, Goals!: How to Get Everything You Want Faster Than You Ever Thought Possible, Berrett-Koehler Publishers, 2021.
- R3. Robin Sharma, The 5 AM Club: Own Your Morning, Elevate Your Life, HarperCollins, 2020.
- R4. Carol S. Dweck, Mindset: The New Psychology of Success, Random House, 2016.
- R5. Daniel H. Pink, Drive: The Surprising Truth About What Motivates Us, Riverhead Books, 2018.
- R6. John C. Maxwell, Leadershift: 11 Essential Changes Every Leader Must Embrace, Harper Collins, 2019.

Online Resources:

1. Coursera – *Personal Development Specialization* (<https://www.coursera.org>)
2. edX – *Leadership and Emotional Intelligence Courses* (<https://www.edx.org>)
3. FutureLearn – *Mindfulness and Resilience Training* (<https://www.futurelearn.com>)
4. MindTools – Practical resources on leadership, communication, and emotional intelligence (<https://www.mindtools.com>)
5. Positive Psychology – Articles and tools on resilience, gratitude, and well-being (<https://positivepsychology.com>)
6. TED Talks – Inspirational talks on leadership, communication, and self-growth (<https://www.ted.com>)
7. Harvard Business Review (HBR) – Leadership, negotiation, and workplace communication (<https://hbr.org>)

25HS203	M.Tech., II-SEMESTER YOGA AND MEDITATION (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (AUDIT COURSE-II)	L	T	P	C
		2	0	0	0

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Explain the eight limbs of Ashtanga Yoga and their significance in achieving physical, mental, and spiritual well-being.
- CO2.** Explain the principles of Yama and Niyama and their role in ethical and personal discipline in yoga practice.
- CO3.** Practice the principles of Yama and Niyama as ethical guidelines for disciplined and harmonious living.
- CO4.** Explain the role of Asana and Pranayama in promoting physical fitness and mental well-being.
- CO5.** Practice yoga poses and pranayama techniques and their benefits for mind and body.

SYLLABUS:

UNIT-I: ASHTANGA YOGA

(05 Periods)

Definitions of Eight parts of yoga - Yama (Restraints / Moral Disciplines), Niyama (Observances / Personal Disciplines), Asana (Postures / Physical Exercises), Pranayama (Breath Control / Life Force Regulation), Pratyahara (Withdrawal of Senses / Sense Control), Dharana (Concentration / Focus), Dhyana (Meditation / Contemplation), Samadhi (Absorption / Liberation)

UNIT-II: YAMA AND NIYAMA IN ASHTANGA YOGA

(07 Periods)

Yama (Moral Restraints) - Ahimsa (Non-violence), Satya (Truthfulness), Asteya (Non-stealing), Brahmacharya (Moderation / Celibacy), Aparigraha (Non-possessiveness / Non-greed).
Niyama (Personal Disciplines / Observances) - Shaucha (Cleanliness / Purity), Santosha (Contentment), Tapas (Discipline / Austerity), Swadhyaya (Self-study / Study of Scriptures), Ishwar Pranidhana (Surrender to God / Devotion).

UNIT-III: DO'S AND DON'TS IN LIFE – YAMA AND NIYAMA

(06 Periods)

Do's and Don'ts in life.

UNIT-IV: ASANA AND PRANAYAM

(06 Periods)

Asana - Body development and steadiness; Pranayam - Breath control and energy regulation

UNIT-V: YOGA POSES AND PRANAYAMA – BENEFITS AND TYPES

(06 Periods)

Various yoga poses and their benefits for mind and body
Regularization of breathing techniques and its effects-Types of pranayama

Total Periods: 30

Text Books:

- T1. Swami Prabhavananda and Christopher Isherwood (translation & commentary), Patanjali Yoga Sutras, Sri Ramakrishna Math, 1953.
- T2. B.K.S. Iyengar, Light on Yoga, Thorsons, 2003.

Reference Books:

- R1. T.K.V. Desikachar, The Heart of Yoga: Developing a Personal Practice, Inner Traditions 2nd Edition, 1999.
- R2. Acharya Yatendra, Yoga & Stress Management, Fingerprint Publishers, 2019
- R3. Yamini Muthanna, The Power of Yoga, Om Books International, 2015.
- R4. Nayaswami Devarshi, Kriya Yoga: Spiritual Awakening for the New Age, Ananda Sangha Publications, 2023.

Online Resources:

1. NPTEL / SWAYAM Online Courses – Yoga and Physical Education modules.
2. AYUSH Ministry Website: <https://yoga.ayush.gov.in> – official yoga resources, protocols, and research.
3. Yoga Journal: <https://www.yogajournal.com> – practical guides, research updates, asana tutorials.
4. Art of Living Foundation: <https://www.artofliving.org> – pranayama, meditation, and wellness practices.
5. YouTube Channels (scholarly & practice-based):
 - a. Sivananda Yoga Vedanta Centre
 - b. Yoga with Adriene (for practical asana guidance)

2599301	M.Tech., III -SEMESTER ECONOMICS AND FINANCING OF RENEWABLE ENERGY SYSTEMS (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: ENERGY AUDIT AND MANAGEMENT

COURSE OUTCOMES:

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

- CO1.** Understand the fundamentals of energy economics and apply engineering economic principles to renewable energy systems.
- CO2.** Explain the framework of energy accounting, market structures, and the impact of energy policies and subsidies.
- CO3.** Evaluate the economic and financial feasibility of renewable energy technologies using cost and benefit analysis methods.
- CO4.** Apply econometric and optimization techniques for energy planning, forecasting, and environmental management.
- CO5.** Assess the role of financial incentives, tariffs, and carbon finance in enhancing the viability of renewable energy projects using relevant software tools.

SYLLABUS:

UNIT-I: ENERGY ECONOMICS

(9 Periods)

Basic concepts, energy data, energy cost, energy balance. Relevance of economic and financial viability evaluation of renewable energy technologies, Basics of engineering economics.

UNIT-II: ENERGY ACCOUNTING FRAMEWORK

(9 Periods)

Economic theory of demand, production and cost market structure; National energy map of India, Energy subsidy – National and international perspectives.

UNIT-III: CONCEPTS OF ECONOMIC ATTRIBUTES

(9 Periods)

Calculation of unit cost of power generation from different sources with examples, different models and methods, Social cost – benefit analysis of renewable energy technologies. Financial feasibility evaluation of renewable energy technologies, Technology dissemination models, Volume and learning effects on costs of renewable energy systems, Dynamics of fuel substitution by renewable energy systems and quantification of benefits

UNIT-IV: APPLICATION OF ECONOMETRICS

(9 Periods)

Input and output optimization; energy planning and forecasting - different methods, Economic approach to environmental protection and management.

UNIT-V: FINANCIAL INCENTIVES

(9 Periods)

Fiscal, financial and other incentives for promotion of renewable energy systems and their effect on financial and economic viability, electricity tariff types. Financing of renewable energy systems, Carbon finance potential of renewable energy technologies and impact of other incentives. Software for financial evaluation of renewable energy systems. Case studies on financial and economic feasibility evaluation of renewable energy projects.

Total Periods: 45

TEXT BOOKS

- T1. Benefit-cost Analysis: Financial and Economic Appraisal using Spreadsheets, Campbell, H.F., & Brown, R.P., Cambridge University Press, 2003.

- T2. Financial Evaluation of Renewable Energy Technologies, Kandpal, T.C. & Garg, H.P., Mac Millan India Limited, 2010.
- T3. Financial Evaluation of Renewable Energy Technologies. Park, C.S.X Upper Saddle River, NJ, Prentice Hall. 2002.

REFERENCE BOOKS:

- R1. Ergonomics: How to Design for Ease and Efficiency. Kroemer, K. H., Kroemer, H. B., & Kroemer-Elbert, K. E. Pearson College Division, 2001.
- R2. Energy Economy, Finance and Geostrategy, Dorsman, A.B., Ediger, V.Ş., & Karan, M.B., Springer, 2018.
- R3. Energy Economics: A Modern Introduction Banks, F. E. Springer Science & Business Media, 2012.
- R4. Engineering Economy, Thuesen G. J. and Fabrycky W.J. PrenticeHall India, Ninth Edition, 2001.

2599302	M.Tech., III -SEMESTER ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES: INTRODUCTION TO RENEWABLE ENERGY SYSTEM

COURSE OUTCOMES:

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

- CO1.** Explain the fundamental concepts of global environmental issues, greenhouse effect, ozone depletion, and related environmental legislations.
- CO2.** Analyse the types, sources, and effects of air pollutants and apply appropriate methods for air quality measurement and control.
- CO3.** Examine water pollution characteristics and demonstrate knowledge of water and waste water treatment techniques for pollution control.
- CO4.** Evaluate various solid and hazardous waste management practices for effective treatment, disposal, and energy recovery.
- CO5.** Assess industrial pollution impacts such as noise, radiation, and oil pollution, and propose mitigation strategies through environmental impact assessment and control technologies.

SYLLABUS:

UNIT-I: INTRODUCTION (9 Periods)

Global atmospheric change – greenhouse effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

UNIT-II: AIR POLLUTION (9 Periods)

Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion - indoor air quality - control methods and equipment's - issues in air pollution control - air sampling and measurement.

UNIT-III: WATER POLLUTION (9 Periods)

Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT-IV: WASTE MANAGEMENT (9 Periods)

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization.

UNIT-V: OTHER TYPES OF POLLUTION FROM INDUSTRIES (9 Periods)

Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies. Radiation pollution: types, sources, effects, control of radiation pollution.

Total Periods: 45

TEXT BOOKS

- T1.** Environmental Engineering – A Design Approach, Arcadio P Sincero and G.A. Sincero, Prentice Hall of India Pvt. Ltd, New Delhi, 2002.
- T2.** Pollution Prevention: Fundamentals and Practice, Bishop P., McGraw-Hill Book Co, Singapore, International Edition, 2000.

T3. Introduction to Environmental Engineering and Science, G. Masters, Prentice Hall of India Pvt. Ltd, New Delhi, 2003.

REFERENCE BOOKS

- R1. Introduction to Environmental Engineering and Science, Gilbert M. Masters, Prentice Hall, Second Edition, 1998.
- R2. Manual of Environmental Technology in Developing Countries, H. Ludwig, W. Evans and Absecon Highlands N.J., International Book Company, 1991.
- R3. Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous, McGraw- Hill Book Company, New York, 2011.
- R4. Environmental Pollution Control Engineering, Rao C.S., New Age International Publishers, Second Edition, 2006.

2599303	M.Tech., III -SEMESTER FUELS AND COMBUSTION TECHNOLOGY (PEC-V) (RENEWABLE ENERGY)	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE OUTCOMES:

- CO1.** Explain the types, composition, and key properties of solid, liquid, and gaseous fuels, and their relevance to energy applications.
- CO2.** Analyze the origin, properties, and processing methods of coal, including carbonization gasification, and liquefaction processes.
- CO3.** Describe the origin, classification, and refining processes of petroleum, and evaluate the characteristics of petroleum products.
- CO4.** Compare natural and synthetic gaseous fuels based on composition, reserves, and energy potential, and assess their suitability as alternative energy sources.
- CO5.** Apply principles of combustion and evaluate pollutant formation and emission control methods in fuel combustion systems.

SYLLABUS:

UNIT-I: BASICS OF FUELS

(9 Periods)

Modern concepts of fuel, Solid, liquid and gaseous fuels, composition, basic understanding of various properties of solid fuels - heating value, ultimate analysis, proximate analysis, ash deformation points; liquid fuels - heating value, density, specific gravity, viscosity, flash point, ignition point (self, forced), pour point, ash composition and gaseous fuels.

UNIT-II: COAL AS A SOURCE OF ENERGY

(9 Periods)

Coal reserves – World and India, Coal liquefaction process, various types of coal and their properties, Origin of coal, composition of coal, analysis and properties of coal, Action of heat on coal, caking and coking properties of coal; Processing of coal: Coal preparations, briquetting, carbonization, gasification and liquefaction of coal, Coal derived chemicals.

UNIT-III: PETROLEUM AS A SOURCE OF ENERGY

(9 Periods)

Origin, composition, classification of petroleum, grading of petroleum; Processing of petroleum: Distillation of crude petroleum, petroleum products, purification of petroleum products – thermal processes, catalytic processes, specifications and characteristics of petroleum products.

UNIT-IV: NATURAL GAS AND ITS DERIVATIVES

(9 Periods)

Classification of gaseous fuels – natural gas and synthetic gases, Natural gas reserves - World and India, properties of natural gas – heating value, composition and density.

UNIT-V: PRINCIPLES OF COMBUSTION

(9 Periods)

Chemistry and Stoichiometric calculation, thermodynamic analysis and concept of adiabatic flame temperature; Combustion appliances for solid, liquid and gaseous fuels: working, design principles and performance analysis.

Emissions from fuel combustion systems: Pollutants and their generation, allowed emissions, strategies for emission reduction, Euro and BIS norms for emission, recent protocols.

Total Periods: 45

TEXT BOOKS:

- T1. Combustion Technology: Essentials of Flames and Burners, Raghavan, V., John Wiley & Sons, 2016.
- T2. Fuels and Combustion, Sharma, S. P., & Mohan, C., Tata McGraw Hill, 2014.

T3. Fuels and Combustion, Sarkar, S. Universities Press. Orient Longman, 2018.

REFERENCES:

- R1. Handbook of Petroleum Technology, Hsu, C. S., & Robinson, P. R., Springer, 2017.
- R2. Oxy- fuel Combustion: Fundamentals, Theory and Practice., Zheng, C., & Liu, Z., Academic Press, 2017.
- R3. Characteristics and Control of Low Temperature Combustion Engines, Maurya, R. K., & Luby, Springer, 2018.

2559351	M.Tech., III-SEMESTER DISSERTATION PHASE-I (RENEWABLE ENERGY)	L	T	P	C
		0	0	20	10

PRE-REQUISITES: COMPLETION OF I & II SEMESTER COURSES

Course Outcomes:

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

- CO1.** Identify and formulate a research problem in the chosen area of specialization through comprehensive literature review.
- CO2.** Analyze existing methods and technologies related to the problem and identify research gaps.
- CO3.** Design a suitable methodology, framework, or experimental setup to address the identified research problem.
- CO4.** apply appropriate tools and techniques to understand and analyze the problems following professional ethics with focus on societal and environmental aspects.
- CO5.** prepare and present a detailed project proposal and preliminary results effectively through technical reports and seminars.
- CO6.** make decisions to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

2559352	M.Tech., III-SEMESTER INDUSTRY INTERNSHIP (RENEWABLE ENERGY)	L	T	P	C
		0	0	0	2

Pre-Requisites: ALL COURSES

Course Outcomes:

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

- CO1.** Demonstrate the organizational structure, workflow, and professional practices followed in industry.
- CO2.** Apply engineering knowledge and technical skills to solve real-world industrial problems.
- CO3.** Develop professional competencies such as teamwork, communication, time management, and work ethics in an industrial environment.
- CO4.** Prepare and present a comprehensive report reflecting practical learning, observations, and outcomes.

2559353	M.Tech., III-SEMESTER CO-CURRICULAR ACTIVITIES (RENEWABLE ENERGY)	L	T	P	C
		0	0	0	1

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Demonstrate participation and engagement in technical and professional co-curricular activities such as seminars, workshops, competitions, and technical events.
- CO2.** Develop problem-solving, analytical, and innovation skills through active involvement in technical activities.
- CO3.** Enhance communication, leadership, teamwork, and organizational skills through collaborative participation in co-curricular programs.
- CO4.** Apply acquired knowledge and skills to improve overall professional competence and lifelong learning abilities.

2512381	M.Tech., III-SEMESTER GREEN BUILDINGS (Common to AIDS, PS, RE, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Apply principles of green building design to plan and evaluate sustainable buildings by integrating energy efficiency, water conservation, eco-friendly materials, and sustainable construction practices.
- CO2.** Explain green building concepts, rating systems, and sustainable practices for energy, water, and materials efficiency.
- CO3.** Apply green building design principles to reduce energy demand and integrate renewable and onsite energy systems efficiently.
- CO4.** Apply energy-efficient HVAC design principles for sustainable air conditioning and green building performance.
- CO5.** Apply material conservation strategies and indoor environmental quality principles to promote sustainable and healthy buildings.

SYLLABUS:

UNIT-I: INTRODUCTION TO GREEN BUILDING AND SUSTAINABLE FEATURES

(08 Periods)

Introduction to Green Building – Necessity of Green Buildings, Benefits of Green Buildings, Green Building Materials and Equipment in India, Key Requisites for Constructing a Green Building, Important Sustainable Features for Green Buildings.

UNIT-II: GREEN BUILDING CONCEPTS AND SUSTAINABLE PRACTICES

(09 Periods)

Green Building Concepts and Practices – Indian Green Building Council, Green Building Movement in India, Benefits Experienced in Green Buildings, Launch of Green Building Rating Systems, Residential Sector, Market Transformation; Green Building Opportunities and Benefits: Opportunities of Green Buildings, Green Building Features, Material and Resources, Water Efficiency, Optimum Energy Efficiency, Typical Energy-Saving Approaches in Buildings, LEED India Rating System, and Energy Efficiency.

UNIT-III: GREEN BUILDING DESIGN AND ENERGY OPTIMIZATION

(09 Periods)

Green Building Design – Introduction, Reduction in Energy Demand, Onsite Sources and Sinks, Maximizing System Efficiency, Steps to Reduce Energy Demand and Use Onsite Sources and Sinks, Use of Renewable Energy Sources, Eco-friendly Captive Power Generation for Factories, Building Requirements.

UNIT-IV: AIR CONDITIONING AND ENERGY-EFFICIENT BUILDING SYSTEMS

(09 Periods)

Air Conditioning – Introduction, CII Godrej Green Business Centre, Design Philosophy, Design Interventions, Energy Modeling, HVAC System Design, Chiller Selection, Pump Selection, Selection of Cooling Towers, Selection of Air Handling Units, Pre-cooling of Fresh Air, Interior

Lighting Systems, Key Features of the Building, Eco-friendly Captive Power Generation for Factories, Building Requirements.

**UNIT-V: MATERIAL CONSERVATION AND INDOOR ENVIRONMENTAL QUALITY
(09 Periods)**

Material Conservation – Handling of Non-Process Waste, Waste Reduction During Construction, Materials with Recycled Content, Local Materials, Material Reuse, Certified Wood, Rapidly Renewable Building Materials and Furniture. Indoor Environment Quality and Occupational Health – Air Conditioning, Indoor Air Quality, Sick Building Syndrome, Tobacco Smoke.

Total Periods: 45

Text Books:

- T1.** Handbook on Green Practices published by Indian Society of Heating Refrigerating and Air conditioning Engineers, 2009.
- T2.** Green Building Hand Book , Tomwoolley and Samkimings, 2009.

References:

- R1.** Complete Guide to Green Buildings, Trish riley
- R2.** Standard for the design for High Performance Green Buildings, Kent Peterson, 2009
- R3.** Energy Conservation Building Code –ECBC-2020, BEE.

2512382	M.Tech., III-SEMESTER	L	T	P	C
	ROAD SAFETY ENGINEERING (Common to AIDS, PS, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Analyze accident data to identify causes and recommend safety improvements.
- CO2.** Apply statistical methods to analyze traffic data and improve accident prevention measures.
- CO3.** Analyze vehicle, human, and geometric design factors to recommend safe road design and traffic control measures.
- CO4.** Classify traffic signs and road markings and evaluate their design and role in enhancing road safety.
- CO5.** Evaluate traffic management systems, road safety audit processes, and ITS applications to improve road safety performance.

SYLLABUS:

UNIT-I: ACCIDENT INVESTIGATION AND ROAD SAFETY RISK MANAGEMENT

(08 Periods)

Accident Investigations and Risk Management, Collection of Accident Data, Assessment of Road Safety, Methods to Identify and Prioritize Hazardous Locations and Elements, Determine Possible Causes of Crashes, Crash Reduction Capabilities and Countermeasures, Effectiveness of Safety Design Features, Accident Reconstruction, Condition and Collision Diagram.

UNIT-II: TRAFFIC ENGINEERING AND STATISTICAL ANALYSIS IN ROAD SAFETY

(09 Periods)

Traffic Engineering Studies; Statistical Methods In Traffic Safety Analysis – Regression Methods, Poisson Distribution, Chi- Squared Distribution, Statistical Comparisons- Traffic Management Measures And Their Influence On Accident Prevention.

UNIT-III: ROAD SAFETY IN TRANSPORT PLANNING AND GEOMETRIC DESIGN

(09 Periods)

Road Safety in ` Transport Planning and Geometric Design: Vehicle and Human Characteristics, Road Design and Safety Elements, Redesigning Junctions, Cross Section Improvements, Traffic Control, Traffic Calming Measures, Road Safety Furniture

UNIT-IV: ROLE OF SIGNS AND MARKINGS IN SAFETY

(08 Periods)

Types of Signs – Design Specifications – Guidelines for Installation – Role of Signs in Safety; Types of Road Markings – Design Specifications – Role of Road Markings in Safety.

UNIT-V: TRAFFIC MANAGEMENT SYSTEMS AND ROAD SAFETY AUDIT

(10 Periods)

Traffic Management Systems for Safety, Road Safety Audits and Tools for Safety Management Systems, Road Safety Audit Process, Road Safety Improvement Strategies, ITS and Safety.

Total Periods: 45

Text Books:

T1. Traffic Engineering and Transportation Planning, L.R. Kadiyali, Khanna Publishers

T2. Fundamentals of Transportation Engineering, C.S.Papacostas, Prentice Hall India.

T3. Road Safety by NCHRP

References:

R1. Transportation Engineering - An Introduction, C.Jotin Khisty, B. Kent Lall

R2. Fundamentals of Traffic Engineering, Richardo G Sigua

R3. Handbook of Road Safety Measures, Second Edition, Rune Elvik, Alena Hoye, TrulsVaa,
Michael Sorenson

2598381	M.Tech., III-SEMESTER ADVANCED DATA STRUCTURES AND ALGORITHMS (Common to PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Implement and manipulate linear data structures like singly/doubly linked lists, circular lists, stacks, and queues using dynamic memory allocation.
- CO2.** Apply and analyze searching and sorting algorithms including linear, binary search, bubble, selection, insertion, quick, and merge sort.
- CO3.** Design and implement dictionaries and hashing techniques to efficiently store and retrieve data.
- CO4.** Construct and operate on trees and priority queues, performing insertion, deletion, and traversal operations.
- CO5.** Compare and implement balanced search trees (AVL, Red-Black, Splay, B-Trees) for optimized data access and storage.

SYLLABUS:

UNIT-I: INTRODUCTION

(09 Periods)

Introduction to Data Structures, Singly Linked Lists, Doubly Linked Lists, Circular Lists- Algorithms. Stacks and Queues: Algorithm Implementation using Linked Lists.

UNIT-II: SEARCHING AND SORTING

(09 Periods)

Linear and Binary Search Methods, Sorting: -Basic sorting techniques, Radix Sort, Bucket Sort, Shell Sort Trees- Binary trees, Properties, Representation and Traversals, Expression Trees (Infix, prefix, postfix). Graphs-Basic Concepts, Storage structures and Traversals.

UNIT-III: DICTIONARIES AND HASHING

(09 Periods)

Dictionaries: Definition, Dictionary Abstract Data Type, Implementation of Dictionaries. Hashing: Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing

UNIT-IV: PRIORITY QUEUES

(09 Periods)

Definition, ADT, Realizing a Priority Queue Using Heaps, Definition, Insertion, Deletion .Search Trees- Binary Search Trees, Definition, ADT, Implementation, Operations-Searching, Insertion, Deletion.

UNIT-V: SEARCH TREES

(09 Periods)

AVL Trees, Definition, Height of AVL Tree, Operations-, Insertion, Deletion and Searching, Introduction to Red-Black and Splay Trees, B-Trees, Height of B-Tree, Insertion, Deletion and Searching, Comparison of Search Trees.

Total Periods: 45

Text Books:

- T1.** Data Structures: A Pseudo Code Approach, Richard F.Gilberg, Behrouz A. Forouzon and Cengage, 2/e.
- T2.** Data Structures, Algorithms and Applications in java, SartajSahni, University Press, 2/e.

Reference Books:

- R1.** Data Structures and Algorithm Analysis, Mark Allen Weiss, Pearson, 2/e.
- R2.** Data Structures and Algorithms, Adam Drozdek, Cengage, 3/e,
- R3.** C and Data Structures: A Snap Shot Oriented Treatise using Live Engineering Examples, N.B.Venkateswarulu, E.V.Prasad and S Chand & Co.

2598382	M.Tech., III-SEMESTER	L	T	P	C
	CLOUD COMPUTING (Common to PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Explain cloud computing fundamentals including characteristics, deployment and service models, multitenancy, cloud economics, networking role, and platforms such as Amazon EC2, Google App Engine, and Microsoft Azure.
- CO2.** Demonstrate virtualization concepts including server, storage, network and service virtualization, virtual machines, virtualization management, performance measurement, and hypervisors such as KVM, Xen, and VMware ESXi.
- CO3.** Explain relational databases, cloud file systems such as Google File System and Hadoop Distributed File System, data models including Bigtable, Apache HBase, Amazon Dynamo, and the MapReduce model with its parallel computing efficiency.
- CO4.** Explain cloud security fundamentals, including security architecture, vulnerability assessment, privacy, trusted computing, secure execution environments, identity and access management, and autonomic security.
- CO5.** Analyze issues in cloud computing including real-time application deployment, inter-cloud challenges, QoS and monitoring, dependability, data migration, streaming, and the role of cloud middleware.

SYLLABUS:

UNIT-I: CLOUD COMPUTING FUNDAMENTALS (09 Periods)

Definition, characteristics, components, Cloud service provider, the role of networks in Cloud computing, Cloud deployment models- private, public & hybrid, Cloud service models, multitenancy, Cloud economics and benefits, Cloud computing platforms - IaaS: Amazon EC2, PaaS: Google App Engine, Microsoft Azure, SaaS.

UNIT-II: VIRTUALIZATION TECHNOLOGIES (09 Periods)

Virtualization concepts, Server virtualization, Storage virtualization, Storage services, Network virtualization, Service virtualization, Virtualization management, Virtualization technologies and architectures, virtual machine, Measurement and profiling of virtualized applications. Hypervisors: KVM, Xen, VMware hypervisors and their features.

UNIT-III: DISTRIBUTED DATA MANAGEMENT AND PROCESSING (09 Periods)

Relational databases, Cloud file systems: GFS and HDFS, Bigtable, HBase and Dynamo. MapReduce and extensions: Parallel computing, the map -Reduce model, Parallel efficiency of Map Reduce.

UNIT-IV: CLOUD SECURITY (09 Periods)

Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud. Cloud computing security architecture: General Issues, Trusted Cloud computing, Secure Execution Environments and Communications, Micro - architectures; Identity Management and Access control, Autonomic security.

UNIT-V: ADVANCED CLOUD COMPUTING ISSUES**(09 Periods)**

Issues in cloud computing Implementing real time application over cloud platform, Issues in Inter - cloud environments, QOS Issues in Cloud, Dependability, data migration, streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment. Cloud Middleware.

Total Periods: 45**Text Books:**

- T1.** Enterprise Cloud Computing, Gautam Shroff, Cambridge publication.
- T2.** Enterprise Cloud Computing Technology Architecture Applications, Gautam Shroff, Cambridge University Press; 1 edition, [ISBN: 978-0521137355], 2010.

Reference Books:

- R1.** Cloud Security, Ronald Krutz and Russell Dean Vines, Wiley -India.
- R2.** Cloud Computing, Dr. Kumar Saurabh, Wiley Publication.
- R3.** Cloud Computing Strategies, Dimitris N. Chorafas, CRC Press; 1 edition [ISBN: 1439834539],2010
- R4.** Cloud Computing, A Practical Approach, Toby Velte, Anthony Velte, Robert Elsenpeter, McGraw Hill Osborne Media; 1 edition [ISBN: 0071626948], 2009.
- R5.** Cloud Computing: Principles and Paradigms, Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley Publication, 2011.
- R6.** Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, Subra Kumaraswamy, Shahed Latif, O'Reilly Media Inc, 2009.

2598383	M.Tech., III-SEMESTER AI TOOLS (Common to PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Explain the fundamentals and evolution of AI tools.
- CO2.** Use AI tools for text, language, and communication tasks.
- CO3.** Apply AI tools for image, audio, and video generation.
- CO4.** Utilize AI tools for coding, research, and productivity enhancement.
- CO5.** Analyze ethical, security, and application-oriented aspects of AI tools.

SYLLABUS:

UNIT-I: INTRODUCTION TO AI TOOLS (09 Periods)

Definition of Artificial Intelligence, Evolution of AI and Intelligent Systems, Categories of AI Tools (Generative, Analytical, Assistive), Rule-based vs Learning-based AI Tools, Overview of Machine Learning & Deep Learning Tools, AI Tool Ecosystem (OpenAI, Google, Meta, Microsoft), Cloud-based AI Tools, Future Trends in AI Tool Development.

UNIT-II: TEXT & LANGUAGE AI TOOLS (09 Periods)

Natural Language Processing (NLP) Basics, ChatGPT – Architecture and Capabilities, Prompt Engineering Concepts, AI Tools for Content Writing, AI Tools for Email, Resume & Report Generation, AI-based Translation and Summarization Tools, AI Chatbots and Virtual Assistants, Limitations and Bias in Language AI Tools.

UNIT-III: IMAGE, AUDIO & VIDEO AI TOOLS (09 Periods)

Image Generation Tools (DALL·E, Midjourney, Stable Diffusion), Image Editing and Enhancement using AI, AI Tools for Graphic Design & Posters, Text-to-Speech AI Tools (ElevenLabs, Google TTS), Speech-to-Text AI Tools, AI-based Video Creation Tools, Avatar and Animation AI Tools, Applications in Media, Education & Healthcare.

UNIT-IV: AI TOOLS FOR CODING, RESEARCH & PRODUCTIVITY (09 Periods)

AI Tools for Programming Assistance, Code Generation and Debugging using AI, AI Tools for Data Analysis, AI Tools for Research Paper Writing, AI Tools for Literature Survey and Citations, AI in Project Management, AI Tools for Presentation Creation, AI Tools for Automation and Workflow Optimization.

UNIT-V: ETHICAL, SECURITY & APPLIED AI TOOLS (09 Periods)

Ethical Issues in AI Tool Usage, Data Privacy and Security Concerns, AI Tool Regulations and Policies, AI Tools in Education, AI Tools in Healthcare, AI Tools in Finance and Business, AI Tools in Smart Cities and Governance, Responsible and Sustainable AI Practices.

Total Periods: 45

Text Books:

- T1.** Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig, Pearson Education, 4th Edition, 2021.
- T2.** AI for Everyone, Michael Miller, Pearson, 2020.
- T3.** Artificial Intelligence for Business, Liam Ottley, Wiley, 2022.

Reference Books:

- R1.** AI Superpowers: China, Silicon Valley, and the New World Order, Kai-Fu Lee, Houghton Mifflin Harcourt, 2018.
- R2.** Artificial Intelligence in Practice, Bernard Marr, Wiley, 2020.
- R3.** Ethical Guidelines for Trustworthy AI, European Commission, 2019.

2584381	M.Tech., III-SEMESTER	L	T	P	C
	IOT AND ITS APPLICATIONS (Common to AIDS, PS, Geo-Tech, RE) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Apply the Knowledge in IOT Technologies and Data management.
- CO2.** Determine the values chains Perspective of M2M to IOT.
- CO3.** Implement the state of the Architecture of an IOT.
- CO4.** Compare IOT Applications in Industrial & real world.
- CO5.** Demonstrate knowledge and understand the security and ethical issues of an IOT.

SYLLABUS:

UNIT-I: FUNDAMENTALS OF IOT (09 Periods)

Evolution of Internet of Things, Enabling Technologies, IoT Architectures, oneM2M, IoT World Forum (IoTWF) and Alternative IoT models, Simplified IoT Architecture and Core IoT Functional Stack, Fog, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects.

IoT Platform overview: Overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards.

UNIT-II: IOT PROTOCOLS (09 Periods)

IT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and Lora WAN, Network Layer: IP versions, Constrained Nodes and Constrained Networks, Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Transport Methods: Supervisory Control and Data Acquisition, Application Layer Protocols: CoAP and MQTT.

UNIT-III: DESIGN AND DEVELOPMENT (09 Periods)

Design Methodology, Embedded computing logic, Microcontroller, System on Chips, IoT system building blocks, Arduino, Board details, IDE programming, Raspberry Pi, Interfaces and Raspberry Pi with Python Programming.

UNIT-IV: DATA ANALYTICS AND SUPPORTING SERVICES (09 Periods)

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest, Role of Machine Learning – No SQL Databases, Hadoop Ecosystem, Apache Kafka, Apache Spark, Edge Streaming Analytics and Network Analytics, Xively Cloud for IoT, Python Web Application Framework, Django, AWS for IoT, System Management with NETCONF-YANG.

UNIT-V: CASE STUDIES/INDUSTRIAL APPLICATIONS (09 Periods)

IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipments. Use of Big Data and Visualization in IoT, Industry 4.0 concepts. Sensors and sensor Node and interfacing using any Embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino).

Total Periods: 45

Text Books:

- T1.** IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017.
- T2.** Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madiseti, Universities Press, 2015.

Reference Books:

- R1.** The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley, 2012 (for Unit 2).
- R2.** From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence, Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier, 2014.
- R3.** Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds), Springer, 2011.

2552381	M.Tech., III-SEMESTER	L	T	P	C
	PHOTOVOLTAIC SYSTEMS (Common to AIDS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Understand solar radiation principles, measurement techniques, and solar cell characteristics and performance.
- CO2.** Explain solar cell manufacturing technologies, PV module design, encapsulation, power rating, hotspot effect, and design qualification standards.
- CO3.** Explain flat plate arrays, mounting structures, module interconnection, lightning protection, and performance evaluation including temperature coefficients, series resistance, and curve correction factors.
- CO4.** Explain photovoltaic system types, design considerations, system, battery and inverter sizing, and balance of system components.
- CO5.** Explain maximum power point tracking techniques, instrument design, and grid-interactive photovoltaic systems.

SYLLABUS:

UNIT-I: SOLAR ENERGY

(09 Periods)

Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

UNIT-II: SOLAR CELLS

(09 Periods)

Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, Encapsulation systems, Manufacture, Power rating, Hotspot effect, Design qualifications.

UNIT-III: PROTECTION AND MEASUREMENTS

(09 Periods)

Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Performance measurement using natural sun light and simulator, Determination of temperature coefficients, Internal series resistance, Curve correction factor.

UNIT-IV: PHOTOVOLTAIC SYSTEMS

(09 Periods)

Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems.

UNIT-V: MAXIMUM POWER POINT TRACKERS

(09 Periods)

Maximum power point trackers, Perturb and observe, Incremental conductance method, Hill climbing method, Hybrid and complex methods, Data based and other approximate methods, Instrument design, Other MPP techniques, Grid interactive PV system.

Total Periods: 45

Text Books:

T1. Generating electricity from Sun, F.C.Treble, Pergamon Press.

T2. Photovoltaic systems: Analysis and design, A.K.Mukherjee, Nivedita Thakur, PHI, 2011.

Reference Books:

R1. Solar Photovoltaics: Fundamentals, Technologies and applications, C.S.Solanki, PHI, 2009.

Online Learning Resources:

1. <https://nptel.ac.in/courses/117108141>

2599381	M.Tech., III-SEMESTER INTEGRATED PRODUCT DESIGN AND DEVELOPMENT (Common to AIDS, PS, Geo-Tech, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

CO1. Explain design concepts, product development planning and customer requirements

CO2. Generate the concept using creative problem solving methods, concept generation and testing.

CO3. Realize Product Teardown, Specifications, Portfolios and Architecture, configurations and prototyping.

CO4. Demonstrate and classify The Design aspects for Risk, Reliability and Safety and environments.

CO5. Do industrial design, understand intellectual property, robust design and product development economics.

SYLLABUS:

UNIT-I: PRODUCT DEVELOPMENT CONCEPTS

(09 Periods)

Design Concepts: Design process – Considerations of a good design – Description of good design process – Design codes and standards. Product Development and Planning Process: Characteristics and challenges of product development – Concept development – Generic product development – Product development process flows –Tyco product development – Product development organizations – Organizational structure and design – Product and process cycles – Technological innovation – Structure of opportunity – Opportunity identification – Product planning process – Types of product development projects. **Identifying Customer Needs:** Process of identifying customer needs – Customer requirements.

UNIT-II: CONCEPT SELECTION, GENERATION AND TESTING

(09 Periods)

Concept Generation: Activity – Concept generation process – Creativity and problem solving – Creative thinking methods and design – Functional decomposition and synthesis – Morphological methods – Axiomatic design.

Concept Selection and Testing: Development process – Choosing a concept – Concept screening and scoring – Decision making and evaluation – Methods for testing product concepts.

UNIT-III: EMBODIMENT AND DETAIL DESIGN

(09 Periods)

Product Teardown, Specifications, Portfolios and Architecture: Teardown process, methods and applications – Post teardown report – Benchmarking approach and support tools for benchmarking process – Product portfolios architecture – Architecture type – Platform architecture – Target Specifications – Setting the final specifications – Modularity – Implications of the architecture – Establishing the architecture – Delayed differentiation – Platform planning – Related system-level design.

Configuration and Detail Design: Generating, analyzing and evaluating configuration design – Best practices for configuration design – Design for X – Design and manufacturing information – Final design review – Activities beyond detail design.

Prototyping: Principles, types and technologies – Understanding prototypes and planning.

UNIT-IV: DESIGN FOR ENVIRONMENT, MANUFACTURING AND SAFETY

(09 Periods)

Design for Manufacture and Environment: Cross-functional team – Overview of DFM process – Life cycles – Environmental impacts – Design for environment process.

Design for Risk, Reliability and Safety: Classification of societal hazards – Standards – Risk assessment – Design for reliability – Causes of unreliability – Minimizing failure – FMEA – Fault tree analysis – Defects and failure modes – Potential dangers – Guidelines for design for safety – Warning labels.

UNIT-V: INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ECONOMICS

(09 Periods)

Industrial Design: Need – Impact – Industrial design process – Management of the industrial design process – Assessing the quality of industrial design. **Robust Design:** Robust design process.

Intellectual Property: Disclosure – Process of pursuing a patent.

Product Development Economics: Elements of economic analysis and process.

Managing Projects: Understanding and representing tasks – Baseline project planning – Accelerating projects – Project execution – Postmortem project evaluation - Project Portfolio Management (PPM) - Earned Value Management (EVM) - Sustainability and ESG in Project Management.

Total Periods: 45

Text Books:

- T1.** Product Design and Development, Karl T Ulrich, Steven D Eppinger and Maria C. Yang, 7/e, 2020, McGraw-Hill Education Pvt.Ltd., Noida.
- T2.** Engineering Design, George E.Dieter and Linda C.Schmidt, 4/e, 2013, McGraw-Hill Education Pvt., Ltd., Noida.

Reference Books:

- R1.** Product Design, Kevin Otto and Kristin Wood, 1/e, 2003, Pearson Education, India.
- R2.** Product Development, Anil Mital, Anoop Desai, Anand Subramanian and Aashi Mital, 1/e, 2007, Butterworth-Heinemann, Elsevier.
- R3.** Integrated Product and Process Design and Development: the Product Realization Process (Special Indian Edition), Edward B. Magrab, Satyandra K. Gupta, F. Patrick McCluskey and Peter A. Sandborn, 2/e, 2010, CRC Press, Taylor & Francis Group, LLC.
- R4.** Product Design for Engineers, Devdas Shetty, 1/e, 2016, Cengage Learning, India.
- R5.** Introduction to Product Design and Development for Engineers, Ali Jamnia, 2018, CRC Press, Taylor & Francis Group, LLC.

Online Learning Resources:

1. https://onlinecourses.nptel.ac.in/noc25_me121/preview
2. https://onlinecourses.swayam2.ac.in/imb25_mg123/preview

25HS381	M.Tech., III-SEMESTER	L	T	P	C
	ADVANCED NUMERICAL METHODS AND COMPUTATIONAL MATHEMATICS (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Analyze conditioning, stability, and error behavior of numerical linear algebra routines for dense and sparse problems.
- CO2.** Derive and apply finite difference for BVP for linear and nonlinear models.
- CO3.** Derive and apply finite difference for PDE models; assess consistency and stability with Lax equivalence and CFL ideas.
- CO4.** Optimize engineering models via unconstrained/constrained methods; justify algorithm selection and tuning using theory and diagnostics.
- CO5.** Integrate GPU/MPI paradigms and the SciPy stack to build scalable, reproducible computational workflows; profile and validate results.

SYLLABUS:

UNIT-I: NUMERICAL LINEAR ALGEBRA (09 Periods)

Floating- point arithmetic, conditioning, stability, backward/forward error; Direct solvers: LU/Cholesky/QR; pivoting and orthogonality; SVD, low- rank approximations, pseudoinverses; Iterative solvers: Jacobi/Gauss–Seidel/CG/GMRES; basic preconditioning; Sparse matrix formats and operations for large- scale systems; Krylov subspace and Arnoldi/Lanczos overviews.

UNIT-II: DISCRETIZATION OF LINEAR AND NONLINEAR ODEs (09 Periods)

Numerical solutions of initial value problems: (single step and multi -step methods); Stability of the numerical methods for initial value problems; Boundary value problems; shooting method; Finite difference for BVP (second and higher order methods), for linear and nonlinear problems Consistency–stability–convergence.

UNIT-III: DISCRETIZATION OF LINEAR AND NONLINEAR PDEs (09 Periods)

Finite difference methods for parabolic problems explicit and implicit methods, Finite difference for hyperbolic explicit and implicit methods; Elliptic PDE; Consistency, Stability and convergence; Lax equivalence and CFL (Courant–Friedrichs–Lewy) ideas; Iterative solvers and multigrid overview for discretized systems.

UNIT-IV: NUMERICAL OPTIMIZATION AND INVERSE PROBLEMS (09 Periods)

Unconstrained methods: gradient, Newton, quasi- Newton, trust- region; Constrained methods: KKT conditions, interior- point, SQP principles; Nonlinear least squares: Gauss–Newton and Levenberg–Marquardt; Regularization (Tikhonov/L1) and model selection concepts; Scientific Python stack:scipy.optimize.minimize, scipy.optimize.linprog, and scipy.optimize.curve_fit; solver choice and diagnostics.

UNIT-V: HIGH- PERFORMANCE SCIENTIFIC COMPUTING (09 Periods)

Parallel paradigms: data/task parallelism; domain decomposition fundamentals; GPU programming model: threads/warps/memory hierarchy; CUDA libraries; MPI and PETSc for scalable sparse linear

algebra and time- steppers; Performance engineering: profiling, locality, and roofline- style thinking; Python at scale: NumPy/SciPy sparse and vectorization; brief Numba/CuPy ecosystem; end-to-end case sketches in CFD/structures/machine learning numerics.

Total Periods: 45

Text Books:

- T1.** Numerical Linear Algebra, Trefethen, L. N., and D. Bau III, Twenty- Fifth Anniversary Edition, SIAM, 2023.
- T2.** Finite Difference Methods for Ordinary and Partial Differential Equations: Steady- State and Time-Dependent Problems, LeVeque, R. J., SIAM, 2007.
- T3.** Numerical Optimization, Nocedal, J., and S. J. Wright, 2nd ed., Springer, 2006.

Reference Books:

- R1.** Programming Massively Parallel Processors: A Hands- on Approach, Hwu, W.- M. W., and D. B. Kirk, 4th ed., Elsevier, 2022.
- R2.** Numerical linera algebra and Application, B. N. dutta, Springer Publications.
- R3.** SciPy Project, Optimization (scipy.optimize), SciPy Manual and Optimization and Root Finding, SciPy 1.16.2 (stable) Reference.
- R4.** PETSc/TAO Users Manual, Balay, S., et al. Argonne National Laboratory, ANL-21/39 Rev 3.18release documentation.
- R5.** Automated Solution of Differential Equations by the Finite Element Method: The FEniCS Book. Logg, A., K.- A. Mardal, and G. N. Wells (eds.). Berlin: Springer, 2012.
- R6.** Numerical analysis Mathematics of scientific computing, David Kincaid Ward Chenery, AMS Book publishers.
- R7.** Computational Methods for Partial Differential Equations, M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age publications.

25HS382	M.Tech., III-SEMESTER	L	T	P	C
	MATHEMATICS FOR MACHINE LEARNING AND DATA SCIENCE (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Analyze linear models and matrix factorizations for dimensionality reduction and feature representation.
- CO2.** Formulate and solve convex and constrained optimization problems; compare first- and second-order methods.
- CO3.** Apply probabilistic modeling, Bayesian inference, and information- theoretic measures to estimation and generalization.
- CO4.** Prove convergence properties or error bounds for selected learning algorithms such as SGD and regularized estimators.
- CO5.** Evaluate and integrate methods into applications such as PCA, SVMs, and neural networks with appropriate regularization.

SYLLABUS:

UNIT-I: LINEAR ALGEBRA FOUNDATIONS

(09 Periods)

Vector spaces, norms, inner products, orthogonality, and projections; Eigenvalues/eigenvectors, spectral theorem, and invariant subspaces; Singular value decomposition, low- rank approximations, and Eckart–Young; Matrix calculus for ML; gradients/Jacobians/Hessians in matrix form; Numerical linear algebra: conditioning, stability, power/QR methods; Feature whitening and centering; PCA link to covariance eigen structure.

UNIT-II: OPTIMIZATION FOR LEARNING

(08 Periods)

Unconstrained methods: gradient descent, line search, Newton/quasi- Newton; Constrained optimization: Lagrange multipliers, projected and barrier methods; Convex sets/functions, KKT conditions for nonlinear programming problems; Regularization: l_1/l_2 penalties, bias–variance trade-offs in risk minimization; Convergence rates and step- size strategies in deterministic models.

UNIT-III: PROBABILITY AND STATISTICAL LEARNING

(10 Periods)

Random variables, expectations, covariance; exponential family basics; Bayesian inference: conjugacy, MAP vs. MLE, posterior predictive analysis; Hypothesis testing and confidence intervals for model comparison; Information measures: entropy, KL divergence, mutual information in learning; Generalization, overfitting, and model selection criteria (e.g., AIC/BIC/VC-style capacity); Concentration and uncertainty quantification for predictions.

UNIT-IV: MODELS AND ALGORITHMS

(09 Periods)

Linear and kernel methods: least squares, logistic regression, and SVMs; Dimensionality reduction: PCA, kernel PCA, and manifold intuition; Probabilistic models: Naive Bayes, Gaussian mixtures, EM overview; Neural network mathematics: backpropagation, initialization, normalization; Regularization schemes: weight decay, early stopping, dropout perspectives.

UNIT-V: INTEGRATIVE APPLICATIONS AND WORKED EXAMPLES (09 Periods)

End-to-end ML pipelines: preprocessing, scaling/whitening, and feature engineering; PCA- based exploration and anomaly detection in high- dimensional data; SVMs and convex models for fault diagnosis and predictive maintenance; Bayesian A/B testing and decision- making under uncertainty; Neural network design trade-offs: capacity, optimization, and generalization; Model evaluation: calibration, ROC/PR analysis, and uncertainty reporting.

Total Periods: 45

Text Books:

- T1.** Mathematics for Machine Learning. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. Cambridge University Press, 2020
- T2.** Probabilistic Machine Learning: An Introduction, Murphy, K. P., MIT Press, 2022.
- T3.** Convex Optimization, Boyd, S., & Vandenberghe, L., Cambridge University Press, 2004.

Reference Books:

- R1.** Deep Learning, Goodfellow, I., Bengio, Y., & Courville, A., MIT Press, 2016
- R2.** Understanding Machine Learning: From Theory to Algorithms. Shalev- Shwartz, S., & Ben- David, S., Cambridge University Press, 2014
- R3.** Principal component analysis: a review and recent developments. Jolliffe, I. T., & Cadima, J., Phil. Trans. R. Soc. A, 2016
- R4.** Elements of Information Theory, Cover, T. M., & Thomas, J. A. 2nd ed. Wiley, 2006.
- R5.** Probabilistic Machine Learning: Advanced Topic, Murphy, K. P. MIT Press, 2023.

25HS383	M.Tech., III-SEMESTER	L	T	P	C
	STATISTICAL LEARNING THEORY AND MATHEMATICAL FOUNDATIONS OF AI (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Analyze probabilistic models, convergence theorems, and stochastic processes underlying learning algorithms.
- CO2.** Formulate and prove generalization bounds using VC dimension, Rademacher complexity, and stability.
- CO3.** Derive and optimize loss/regularization for linear, kernel, and deep models; justify selections by convexity and smoothness properties.
- CO4.** Evaluate algorithms via bias–variance, PAC guarantees, and information- theoretic criteria such as KL and mutual information.
- CO5.** Integrate theory to design robust AI solutions for multi- domain engineering applications and communicate findings effectively.

SYLLABUS:

UNIT-I: PROBABILITY AND MEASURE FOUNDATIONS (09 Periods)

Probability spaces, σ - algebras, random variables; expectation and conditional expectation; Inequalities and concentration: Markov, Chebyshev, Hoeffding; LLN and CLT; Modes of convergence and Borel–Cantelli; almost sure vs in- probability convergence; Random processes and martingale basics; optional stopping; Doob’s inequality (overview); Markov chains: ergodicity, mixing, stationary distributions for modeling sequences.

UNIT-II: STATISTICAL LEARNING THEORY (09 Periods)

PAC learning model, realizable/agnostic cases; sample complexity and no- free- lunch; VC dimension, shattering, Sauer’s lemma; uniform convergence guarantees; Empirical risk minimization and structural risk minimization; capacity control; Rademacher/Gaussian complexities and symmetrization for data- dependent bounds; Algorithmic stability and generalization; regularization and early stopping as capacity control; PAC- Bayes bounds and posterior- based generalization certificates.

UNIT-III: OPTIMIZATION FOR LEARNING (09 Periods)

Convex analysis: Lipschitzness, smoothness, strong convexity; implications for rates; Gradient, stochastic, and variance- reduced methods; step- size and convergence trade-offs; Proximal methods and projected gradients; sparsity via ℓ_1 (Lasso) and shrinkage via ℓ_2 (ridge); Duality and KKT conditions; constrained learning formulations; Nonconvex landscapes in deep networks—saddle points, over-parameterization, and implicit regularization; Generalization–optimization interplay: implicit bias of optimizers.

UNIT-IV: KERNEL AND PROBABILISTIC MODELS (09 Periods)

Reproducing kernel Hilbert spaces, kernel trick, representer theorem; Large- margin methods: SVMs, soft margins, hinge loss; primal–dual views; Gaussian processes: kernels as priors; posterior prediction and uncertainty quantification; Graphical models—Bayesian networks and

Markov/conditional random fields for structured prediction; exact inference (variable elimination, junction tree) and approximate methods (loopy belief propagation, variational); Hidden Markov models; EM for latent- variable learning; Variational inference and message passing for scalable probabilistic AI.

UNIT-V: DEEP LEARNING AND INFORMATION THEORY (09 Periods)

Backpropagation (chain rule), initialization, normalization, and activation design; Loss functions and calibration; cross- entropy, margin losses, and robust objectives; Generalization in deep nets: margins, flat minima, compression, and stability views; Information- theoretic tools: entropy, mutual information, KL divergence; Information bottleneck and representation learning, with links to PAC- Bayes; Worked examples: applying theory to vision, language, and control tasks in engineering.

Total Periods: 45

Text Books:

- T1.** Understanding Machine Learning: From Theory to Algorithms, Shalev- Shwartz, S., Ben- David, S., Cambridge University Press, first edition, 2014.
- T2.** Deep Learning, Goodfellow, I., Bengio, Y., Courville, A., MIT Press, 2016.
- T3.** Pattern Recognition and Machine Learning, Bishop, C. M., Springer, 2006.

Reference Books:

- R1.** The Nature of Statistical Learning Theory, Vapnik, V. N., Springer, 1995/1998.
- R2.** Elements of Information Theory, Cover, T. M., Thomas, J. A., 2nd ed., Wiley, 2006.
- R3.** Foundations of Machine Learning, Mohri, M., Rostamizadeh, A., Talwalkar, A., 2nd ed., MIT Press, 2018.
- R4.** Learning with Kernels: Support Vector Machines, Regularization, Optimization, and Beyond, Schölkopf, B., Smola, A. J., MIT Press, 2002.
- R5.** Gaussian Processes for Machine Learning, Rasmussen, C. E., Williams, C. K. I., MIT Press, 2006.

25HS384	M.Tech., III-SEMESTER CHEMISTRY OF NANOMATERIALS AND APPLICATIONS IN ENGINEERING (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

COURSE OUTCOMES:

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

- CO1.** Explain the basic concepts, scope, natural occurrence, classification, and importance of nanoscience and nanomaterials.
- CO2.** Explain the top-down and bottom-up synthetic methods used for the preparation of nanomaterials.
- CO3.** Understand the principles and applications of various characterization techniques used for analyzing nanomaterials.
- CO4.** Explain the synthesis, properties, and applications of important nanomaterials.
- CO5.** Understand the applications of nanomaterials such as nanoparticles, nanorods, and nanowires in various engineering and technological fields.

SYLLABUS:

UNIT-I: BASICS OF NANOMATERIALS

(08 Periods)

Introduction, Scope of nanoscience and nanotechnology, nanoscience in nature, classification of nanostructured materials, importance of nanomaterials.

UNIT-II: SYNTHESIS OF NANOMATERIALS

(10 Periods)

Top-Down approach, Inert gas condensation, arc discharge method, aerosol synthesis, plasma arc technique, ion sputtering, laser ablation, laser pyrolysis, and chemical vapor deposition method, electrode position method, high-energy ball milling method.

Synthetic Methods: Bottom-Up approach, Sol-gel synthesis, microemulsions or reverse micelles, co-precipitation method, solvothermal synthesis, hydrothermal synthesis, microwave heating synthesis and sonochemical synthesis.

UNIT-III: TECHNIQUES FOR CHARACTERIZATION

(09 Periods)

Diffraction techniques, spectroscopy techniques, electron microscopy techniques for the characterization of nanomaterials, BET method for surface area analysis, dynamic light scattering for particle size determination.

UNIT-IV: STUDIES OF NANO-STRUCTURED MATERIALS

(09 Periods)

Synthesis, properties and applications of the following nanomaterials: fullerenes, carbon nanotubes, 2D-nanomaterial (Graphene), core-shell, magnetic nanoparticles, thermoelectric materials, non-linear optical materials.

UNIT-V: ADVANCED ENGINEERING APPLICATIONS OF NANOMATERIALS

(09 Periods)

Applications of nanoparticles, nanorods, nano wires in Water treatment, sensors, electronic devices, medical domain, civil engineering, chemical engineering, metallurgy and mechanical engineering, food science, agriculture, pollutants degradation.

Total Periods: 45

Text Books:

- T1.** NANO: The Essentials, T Pradeep, MaGraw-Hill, 2007.

T2. Textbook of Nanoscience and nanotechnology, B S Murty, P Shankar, Baldev Rai, BB Rath and James Murday, Univ. Press, 2012.

Reference Books:

R1. Concepts of Nano chemistry; LudovicoCademrtiri and Geoffrey A. Ozin & Geoffrey A. Ozin, Wiley-VCH, 2011.

R2. Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Guozhong Cao, Imperial College Press, 2007.

R3. Nanomaterials Chemistry, C. N. R. Rao, Achim Muller, K.Cheetham, Wiley-VCH, 2007.

25HS385	M.Tech., III-SEMESTER PHOTONICS FOR ENGINEERS (Common to AIDS, PS, Geo-Tech, RE, ES&VLSI) (OPEN ELECTIVE)	L	T	P	C
		3	0	0	3

Pre-Requisites: NIL

Course Outcomes:

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

- CO1.** Describe how light behaves and propagates in optical media.
- CO2.** Explain light–matter interaction mechanisms and analyze the working, characteristics, and applications of LEDs, laser diodes, quantum well lasers and various photodetectors.
- CO3.** Explain key nonlinear effects and analyze the operation of optical modulators and switches such as the Mach–Zehnder Interferometer.
- CO4.** Analyse fiber parameters and explain the functioning of transmitters, receivers, WDM systems, couplers and resonator-based communication devices.
- CO5.** Describe the working of photonic sensors and emerging quantum and ultrafast photonic technologies used in sensing, computation and communication.

SYLLABUS:

UNIT-I: FUNDAMENTALS OF PHOTONICS (09 Periods)

Nature of light: wave-particle duality, polarization, coherence. Maxwell’s equations and wave propagation in dielectric media. Reflection, refraction, (vector notation) interference, diffraction, dispersion and birefringence.

UNIT-II: PHOTONIC DEVICES AND COMPONENTS – I (09 Periods)

Absorption, spontaneous and stimulated emission. Einstein coefficients, population inversion, optical gain. Semiconductor light sources: LEDs, laser diodes, quantum well lasers. Photodetectors: PIN, avalanche photodiodes, photomultiplier tubes.

UNIT-III: PHOTONIC DEVICES AND COMPONENTS – II (09 Periods)

Nonlinear optical effects – second-harmonic generation, Kerr effect, four-wave mixing. Electro-optic Magneto optic and acousto-optic modulation principles. Optical modulators and switches (Mach Zehnder Interferometer).

UNIT-IV: OPTICAL WAVEGUIDES AND APPLICATIONS (09 Periods)

Optical fibers – numerical aperture, V-number, modes, attenuation, dispersion. Fiber-optic communication systems: transmitters, receivers, multiplexing (WDM), optical couplers, ring resonators.

UNIT-V: PHOTONIC SYSTEMS AND APPLICATIONS (09 Periods)

Photonic sensors – interferometric, fiber Bragg gratings, biosensing. Optical signal processing and computing.

Introduction to quantum photonics: single-photon sources, entanglement, and photonic qubits. Plasmonics and metamaterials, Ultrafast and terahertz photonics.

Total Periods: 45

Text Books:

- T1.** Fundamentals of Photonics, B.E.A. Saleh & M.C. Teich., Wiley.
- T2.** Semiconductor Optoelectronics: Physics and Technology, J. Singh, McGraw Hill Edition.
- T3.** Photonics: Optical Electronics in Modern Communications, A. Yariv & P. Yeh, Oxford Series.
- T4.** Optical Fiber Communications, G. Keiser, McGraw Hill Edition.

Reference Books:

- R1.** Optoelectronics: An Introduction, J. Wilson & J.F.B. Hawkes.
- R2.** Nonlinear Optics, R.W. Boyd.
- R3.** Electromagnetic waves and radiating systems E. Jordan.

2599451	M.Tech., IV-SEMESTER DISSERTATION PHASE-II (RENEWABLE ENERGY)	L	T	P	C
		0	0	32	16

Pre-Requisites: All Courses

Course Outcomes:

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

- CO1.** Implement the proposed methodology or design to develop a functional solution or prototype for the identified research problem.
- CO2.** Analyze and evaluate the results using appropriate tools, techniques, or experimental methods.
- CO3.** Interpret results and draw meaningful conclusions with respect to the objectives of the research work.
- CO4.** Prepare a comprehensive project report and effectively present the research findings through seminars and viva voce.
- CO5.** make decisions to manage tasks and also engage in independent and life-long learning with ability to adapt to new and technological changes.

