DEPARTMENT OF PHYSICS

Curriculum and Syllabus for

BVoc Renewable Energy Management Programme

Under Choice Based Credit System

(Outcome Based Education with Effect from 2022 Admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
CHANGANASSERY, KERALA

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Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

REGULATIONS FOR BVoc PROGRAMME IN RENEWABLE ENERGY MANAGEMENT UNDER CREDIT SEMESTER SYSTEM (SB-CSS-BVoc) 2022

1. **SHORT TITLE**

1.1 These Regulations shall be called St. Berchmans college (Autonomous) Regulations (2022) governing BVoc Programmes under the Credit Semester System (SB-CSS-BVoc)

1.1 These Regulations shall come into force from the Academic Year 2022-23 admissions onwards.

2. **SCOPE**

1.2 The regulation provided herein shall apply to BVoc programme in Renewable Energy Management conducted by St. Berchmans College (Autonomous) with effect from the academic year 2022 – 23 admissions onwards.

3. **DEFINITIONS**

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

3.2 'College' means St. Berchmans College (Autonomous) Changanassery.

3.3 There shall be an Academic Committee nominated by the Principal to look after the matters relating to the SB-CSS-BVoc system.

3.4 'Academic Council' means the Committee consisting of members as provided under section 107 of the Autonomy Ordinance, Government of Kerala.

3.5 'Parent Department' means the Department of Physics.

3.6 'Programme Outcome (PO)' are statements that describes what the students graduating from general programme should be able to do.

3.7 'Programme Specific Outcome (PSO)' are statements that describe what the graduates of a specific programme should be able to do.

3.8 'Course Outcome' are statements that describe what students should be able to do at the end of a course.

3.9 'Programme' means a three year programme of study and examinations.

3.10 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of the BVoc programme shall be three years consisting of six semesters

3.11 'Course' means a segment of subject matter to be covered in a semester. Each Course is to be designed under lectures/laboratory work/seminar/project/practical/assignments/ evaluation etc., to meet effective teaching and learning needs.

3.12 'Course Teacher' means the teacher who is taking classes on the course.

3.13 'Common Course' means a course that comes under the category of courses for English.

3.14 'Project' means a regular project work with stated credits on which the student conducts a project under the supervision of a teacher in the parent department/any appropriate research centre in order to submit a dissertation on the project work as specified.

3.15 'Dissertation' means a minor thesis to be submitted at the end of a research work carried out by each student under the supervision of a teacher in the parent department on a specific area.

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

3.17 'Seminar' means a lecture expected to train the student in self-study, collection of relevant matter from books and internet resources, editing, document writing, typing and presentation.

3.18 'Evaluation' means every student shall be evaluated by in-semester assessment (20%) and end-semester assessment (80%).

3.19 'Improvement Examination' is an examination conducted to improve the performance of a student in the courses of a particular semester.

3.20 'Supplementary Examination' is an examination conducted for students who fail in the courses of a particular semester.

3.21 'Credit' (C) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.22 One Credit would mean equivalent of 14 - 15 periods of 60 minutes each, for lectures, and tutorials. For workshops/labs and internship/field work, the credit weightage for equivalent hours shall be 50% of that for lectures/tutorials. For self-learning, based on e- content or otherwise, the credit weightage for equivalent hours of study should be 50% or less of for lectures/tutorials.

3.23 'Grade' means a letter symbol (A, B, C etc.) which indicates the broad level of performance of a student in a course/semester/programme.

3.24 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.25 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course.

3.26 'Semester Credit Point Average' (SCPA) of a semester is calculated by dividing total credit points obtained by the student in a semester by total credits of that semester and shall be rounded off to two decimal places.

3.27 'Cumulative Credit Point Average' (CCPA) is the value obtained by dividing the sum of credit points in all the courses obtained by the student for the entire programme by the total credits of the whole programme and shall be rounded off to two decimal places.

3.28 'Institution average' is the value obtained by dividing the sum of the marks obtained by all students in a particular course by the number of students in respective course.

3.29 'Grace Marks' means marks awarded to course/courses as per the choice of the student, in recognition of meritorious achievements of a student in NCC/NSS/Sports/Arts and cultural activities.

3.30 Rank certificate shall be issued to candidates who secure positons from one to three. Position certificate shall be issued on request from fourth position to tenth position. Candidates shall be ranked in the order of merit based on the CCPA scored by them.

3.31 Grace marks awarded to students shall not be counted for fixing rank/position. The rank and position certificate shall be signed by the Principal and Controller of Examinations.

4. PROGRAMME STRUCTURE

4.1 The BVoc Programme shall include General Education components and Skill Components. As per UGC regulations for BVoc Programme, the skill component of the courses shall be assessed by the respective Sector Skill Councils.

Study tour/field visit/industrial visit/visit to research institutes/visit to historical places/cultural and heritage centres etc. should be conducted preferably during the fifth semester as part of the curriculum. The credit distribution for the programmes is shown below.

NSQF Level	Normal Calendar Duration	Skill Component Credits	General Education Credit
6 Months	One semester	18	12
Year 1	Two Semesters	36	24
Year 2	Four Semesters	72	48
Year 3	Six Semesters	108	72

4.2 Project, HOT, OJT

All students shall complete one hands-on training (HOT), one on-job training (OJT) and one major project. The major project can be done individually or as a group of 5 students. The HOT and OJT shall be done during the second and fourth semesters of the programme. The major project shall be done in the final year of the programme. The reports of HOT and OJT (in duplicate) shall be submitted to the department in the second and fourth semesters and the report of the major project (in duplicate) shall be submitted to the department in the sixth semester. The reports of HOT, OJT and major project report shall be produced before the examiners appointed by the Controller of Examinations.

4.3 Evaluations

The evaluation of each course shall contain two parts.

i In-Semester Assessment (ISA)

ii End-Semester Assessment (ESA)

Both ISA and ESA shall be carried out using indirect grading. The ISA: ESA ratio shall be 1:4, for all courses including practical (practical courses will be treated as independent courses). There shall be a maximum of eighty (80) marks for external evaluation and twenty (20) marks for internal evaluation.

4.4 In-semester assessment of theory courses

Component	Marks
Attendance	2
Exam 1 & Exam 2 *Marks shall be secured from two examinations based on modern tools	2½ + 2½
Exam 3 (written examination)	5
Quiz/Poster/Seminar/Field report/Group Discussion/Work Book/Assignment/Article Review/Viva (Any two from the above)	4 + 4
Total	20

Marks for attendance

% of Attendance	Marks
Above 90	2
75 – 90	1

(Decimals shall be rounded off to the next higher whole number)

4.5 In-semester assessment of practical courses

ISA - Components of Practical	Marks
Attendance	5
Record	5
Test	5
Performance, Punctuality, Skill and Viva	5
Total	20

4.6 To ensure transparency of the evaluation process, the ISA mark awarded to the students in each course in a semester shall be published on the notice board according to the schedule in the academic calendar published by the College. There shall not be any chance for improvement for ISA. The course teacher and the faculty mentor shall maintain the academic record of each student registered for the course which shall be forwarded to the office of the Controller of Examinations through the Head of the Department and a copy should be kept in the office of the Head of the Department for at least two years for verification.

4.7 A student who has not secured minimum marks in internal examinations can redo the same before the end semester examination of the semester concerned.

4.8 End-semester assessment

The end-semester examination in theory and practical courses shall be conducted by the College.

4.9 The end-semester examinations shall be conducted at the end of each semester. There shall be one end-semester examination of three (3) hours duration in each lecture based course.

4.10 The question paper should be strictly on the basis of model question paper set by Board of Studies.

4.11 A question paper may contain very short answer type, short answer type, short essay type and long essay type questions. The question paper pattern is given below.

Section	Total No. of Questions	No. of Questions to be Answered	Marks	Total Marks for the Section
A	12	10	2	20
B	9	6	5	30
C	4	2	15	30
			Maximum	80

4.12 Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny as per the regulations in the examination manual.

4.13 Practical examination shall be conducted in each semester. The duration and frequency of practical examination shall be decided by the respective Board of Studies.

4.14 Practical examination shall be conducted by one external examiner and one internal examiner. The question paper setting and evaluation of answer scripts shall be done as per the directions in

the examination manual of the College.

4.15 Project Evaluation

The project report shall be subject to internal and external evaluation followed by a viva-voce at the end of the programme. Internal Evaluation is to be done by the supervising teacher and external evaluation by an external evaluation board consisting of an examiner appointed by the College and the Head of the Department or his nominee. A viva-voce related to the project work shall be conducted by the external evaluation board and students shall attend the viva-voce individually.

Components of Project Evaluation	Marks
Internal Evaluation	20
Dissertation and Industry/Institution Visit Report	50
Viva-Voce	30
Total	100

In exceptional circumstances like natural calamities, epidemics, pandemics etc. viva / OJT may be conducted through online mode also. Head of the Department shall make the arrangement for conducting the viva/OJT examinations through online. The entire proceedings shall be recorded and the soft copy shall be submitted to the Controller of Examinations. The external examiner, internal examiner and the student may attend the viva voce through online.

4.16 If the student fails in project evaluation, he or she shall submit the project report after modifying it on the basis of the recommendations of the examiners.

4.17 For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
35 to below 45	D	Pass	4
Below 35	F	Failure	0

5. CREDIT POINT AND GRADE POINT AVERAGE

5.1. Credit Point

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the credit and GP is the grade point

5.2 **Semester Credit Point Average**

Semester Credit Point Average (SCPA) is calculated using the formula

SCPA = TCP/TCS

where TCP is the total credit point of all the courses in the semester and TCS is the total credits in the semester

CPA shall be rounded off to two decimal places.

5.3 **Cumulative Credit Point Average**

Cumulative Credit Point Average (CCPA) is calculated using the formula

CCPA = TCP/TC

where TCP is the total credit point of all the courses in the whole programme and TC is the total credit in the whole programme

CPA shall be rounded off to two decimal places.

5.4 Credit Point Average (CPA) of different category of courses viz. Common Course I, Common Course II, Complementary Course I, Complementary Course II, Vocational Course, Core Course etc. are calculated using the formula

CPA = TCP/TC

where TCP is the Total Credit Point of a category of course and TC is the total credit of that category of course

Grades for the different courses, semesters, Semester Credit Point Average (SCPA) and grades for overall programme, Cumulative Credit Point Average (CCPA) are given based on the corresponding Credit Point Average (CPA) as shown below:

CPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
4 to below 4.5	D	Pass
Below 4	F	Failure

5.5 A separate minimum of 30% marks each for internal and external (for both theory and practical) and aggregate minimum of 35% are required for a pass in a course.

5.6 For a pass in a programme, a separate minimum of grade 'D' is required for all the individual courses.

5.7 If a candidate secures F Grade for any one of the courses offered in a semester/programme, only F grade will be awarded for that semester/programme until the student improves this to D grade or above within the permitted period.

5.8 Candidate who secures D grade and above will be eligible for higher studies.

6 SUPPLEMENTARY/IMPROVEMENT EXAMINATION

There will be supplementary examinations and chance for improvement. Only one chance will be given for improving the marks of a course.

7 ATTENDANCE

7.1 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of ten (10) days or 50 hours in a semester subject to a maximum of two times during the whole period of undergraduate programme may be granted by the College.

7.2 If a student represents the College, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union/University union activities etc., he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of ten (10) days in a semester based on the specific recommendations of the Head of the Department.

7.3 A student who does not satisfy the requirements of attendance shall not be permitted to appear for the end-semester examinations.

7.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch.

8 BOARD OF STUDIES AND COURSES

8.1 The Board of Studies in Physics shall design all the courses offered in the BVoc programme. The Board shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposure and training for the students.

8.2 The syllabus of a course shall include the title of the course, contact hours, the number of credits and reference materials.

8.3 Each course shall have an alpha numeric code which includes abbreviation of the course in two letters, the semester number, code of the course and the serial number of the course.

8.4 Every Programme conducted under Credit Semester System shall be monitored by the Academic Council.

9 REGISTRATION

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

9.2 A student may be permitted to complete the programme, on valid reasons, within a period of twelve (12) continuous semesters from the date of commencement of the first semester of the

programme.

9.3 Those students who possess the required minimum attendance and progress during an academic year/semester and could not register for the annual/semester examination in time are permitted to apply for Notional Registration to the examinations concerned enabling them to get promoted to the next semester.

10 ADMISSION

10.1 The admission to BVoc programme shall be as per the rules and regulations of the College/University.

10.2 Candidates should have passed the Plus Two/equivalent examination recognised by the University for admission to BVoc Renewable Energy Management programme.

10.3 Separate rank lists shall be drawn up for seats under reservation quota as per the existing rules.

10.4 There shall be a uniform academic and examination calendar prepared by the College for the conduct of the programmes.

11 ADMISSION REQUIREMENTS

11.1 Candidates for admission to the first semester of the UG programme through SB-CSS- UG shall be required to have passed Plus Two or equivalent examination or any other examination of any recognized authority, accepted by the Academic council of Mahatma Gandhi University as equivalent thereto.

11.2 Students admitted under this programme are governed by the Regulations in force.

12 PROMOTION

A student who registers his/her name for the external examination for a semester will be eligible for promotion to the next semester.

13 MARK CUM GRADE CARD

13.1 The College under its seal shall issue to the students, a Mark cum Grade card on completion of each semester, which shall contain the following information.

i. Name of the Student
ii. Register Number
iii. Photo of the student
iv. Degree
v. Programme
vi. Date of Birth
vii. Date of Eligibility
viii. Semester and Name of the Examination
ix. Month and Year of Examination
x. Stream
xi. Course Code, Title and Credits of each course opted in the semester
xii. Marks for ISA, ESA, Total Marks (ISA + ESA), Maximum Marks, Letter Grade, Grade Point (GP), Credit Point (CP) and Institution Average in each course opted in the semester
xiii. Total Credits, Marks Awarded, Credit Point, SCPA and Letter Grade in the semester
xiv. Result

13.2 The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The final Mark Cum Grade Card shall show the CCPA and the overall letter grade of a student for the entire programme.

14 AWARD OF DEGREE

The successful completion of all the courses with 'D' grade shall be the minimum requirement for the award of the degree. The certification levels will lead to Certificate/Diploma/Advanced Diploma/BVoc Degree in one or more vocational areas and will be offered under the aegis of the University. This is outlined in following table.

Award	Duration	Normal Calendar Duration	Corresponding NSQF level
Certificate	6 Months	One semester	4
Diploma	1 Year	Two Semesters	5
Advanced Diploma	2 Years	Four Semesters	6
BVoc Degree	3 Years	Six Semesters	7

Credit Transfer and Accumulation system can be adopted in the programme. Transfer of Credit consists of acknowledging, recognizing and accepting credits by an institution for programmes or courses completed at another institution. The Credit Transfer Scheme shall allow students pursuing a programme in one University to continue their education in another University without break.

15 MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluation conducted by the College. The Course Teacher, Faculty Mentor, and the College Coordinator should keep all the records of the continuous evaluation, for at least a period of two years, for verification.

16 GRIEVANCE REDRESSAL MECHANISM

16.1 In order to address the grievance of students regarding ISA, a two-level Grievance Redressal mechanism is envisaged.

16.2 A student can approach the upper level only if grievance is not addressed at the lower level.

16.3 Department level: The Principal shall form a Grievance Redressal Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

16.4 College level: There shall be a College level Grievance Redressal Committee comprising of course teacher, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

17. TRANSITORY PROVISION

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

PROGRAMME OUTCOMES

PO1: Develop in-depth conceptual knowledge in the discipline for vertical growth and scholarly pursuits

PO2: Identify historical, theoretical, scientific, technological, economic philosophical, cultural, aesthetic and ethical bases of different disciplines and relate them effectively

PO3: Demonstrate problem solving skills, effective communication, interpersonal dynamics and resilience in global and local contexts

PO4: Transfer the knowledge of methods, skills, tools and systems of different disciplines for a sustainable and egalitarian world order

PO5: Generate need based innovative processes and products for personal and societal well-being

PROGRAMME SPECIFIC OUTCOMES

PSO1: **Develop** competency in theoretical and experimental aspects of renewable energy sources, mathematical skills and linguistic proficiency and **apply** them effectively for an energy efficient world.

PSO2: **Describe** and **review** principles and theoretical framework of equally important areas of energy infrastructure, rational use of energy, energy policies and regulations, and energy-environment interface etc.

PSO3: **Acquire** the skills to tackle practical problems of design, development, deployment in the industry, and to pursue academics as well as frontiers of research.

PSO4: **Interpret** theoretical as well as practical aspects of renewable energy technologies, energy conservation, and management and **infer** valid conclusions

PSO5: **Develop** skills through training programs like Hands on Training (HOT), On the Job Training (OJT) in Renewable energy sectors and **create** knowledge through projects that enhances their ability to work.

PROGRAMME STRUCTURE

Semester I

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CCENG101	Basic English Writing	3	56	4	20	80	100
CDMMG101	Mathematics	3	56	4	20	80	100
CBREG101	Units, Measurements and Basics of Renewable Energy	3	56	4	20	80	100
CBRES101	Solar PV Installation: Civil and Mechanical	4	70	5	20	80	100
CBRES102	Solar PV Installation: Operation and Maintenance	4	70	5	20	80	100
CBRES1P01	Practical Solar PV Installation, Operation and Maintenance (P)	12	224	8	20	80	100
	Total	**-**	**-**	**30**	**120**	**480**	**600**

Semester II

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CCENG202	Essential Spoken Skills and Grammar	3	56	4	20	80	100
CDMMG202	Mathematics	3	56	4	20	80	100
CBREG202	Semiconductor Physics	3	56	4	20	80	100
CBRES203	Rooftop Solar Grid Engineering	4	70	5	20	80	100
CBRES204	Energy Storage Systems	4	70	5	20	80	100
CBRES2P02	Grid Tied Solar Photovoltaic System and Basic Electronics Practical (P)	6	112	4	20	80	100
CBRES2HT	HOT	6	112	4	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**

Semester III

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CBREG303	Fundamentals of Computers	3	56	4	20	80	100
CBREG304	Thermodynamics and Fluid Mechanics	3	56	4	20	80	100
CBREG305	Novel Energy Sources	3	56	4	20	80	100
CBRES305	Solar Thermal Technology - I	4	70	5	20	80	100
CBRES306	Wind Energy	4	70	5	20	80	100
CBRES3P03	Thermodynamics and Solar Thermal (P)	6	112	4	20	80	100
CBRES3P04	Fluid Dynamics and Wind Energy (P)	6	112	4	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**

Semester IV

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CBREG406	Analysis of a Solar Thermal system	3	56	4	20	80	100
CBREG407	Materials for Green Energy	3	56	4	20	80	100
CBREG408	Environmental Education	3	56	4	20	80	100
CBRES407	Solar Photovoltaic Energy Conversion – I	4	70	5	20	80	100
CBRES408	Entrepreneurship in Solar PV	4	70	5	20	80	100
CBRES4P05	Solar Photovoltaic (P)	6	112	4	20	80	100
CBRES4OJT	OJT	6	112	4	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**

Semester V

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CBREG509	Lasers and Optical Instrumentation	3	56	4	20	80	100
CBREG510	Environment, Health and Safety in Industries	3	56	4	20	80	100
CBREG511	Project Management	3	56	4	20	80	100
CBRES509	Energy Conservation Techniques	4	70	5	20	80	100
	Choice Based Skill Course	4	70	5	20	80	100
CBRES5P06	Advanced Solar Photovoltaic Lab (P)	4	112	4	20	80	100
CBRES5P07	Advanced Solar Thermal Lab – I (P)	4	112	4	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**

Semester VI

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CBREG612	Biomass Technologies and Geothermal Power Generation	3	56	4	20	80	100
CBREG613	Power Electronics	3	56	4	20	80	100
CBREG614	Fuel Cells and Hydrogen	3	56	4	20	80	100
CBRES610	Energy Management and Auditing	4	70	5	20	80	100
CBRES6P08	Advanced Solar Thermal Lab – II (P)	6	112	4	20	80	100
CBRES6P09	Experimental Techniques and Power Electronics (P)	6	112	4	20	80	100
CBRES6PJ	Project	-	140	5	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**
	Grand Total	-	-	**180**	-	-	**4100**

CHOICE BASED SKILL COURSES

Course Code	Title of the Course	Instructional Hours/week	Instructional Hours for the course	Credit	ISA	ESA	Total
CBRES5E01	Solar Photovoltaic Energy Conversion – II	4	70	5	20	80	100
CBRES5E02	Solar Thermal Technology – II	4	70	5	20	80	100

SEMESTER I

CBREG101: UNITS, MEASUREMENTS AND BASICS OF RENEWABLE ENERGY

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Learn and understand the necessity of units and dimensions

CO2: Apply and analyse different system of units and dimensional analysis to different physical situations

CO3: Obtain a basic understanding of different types of measuring devices.

CO4: Familiarize various energy sources and their availability

CO5: Identify the potential of solar energy and describe its applications.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	-	-	-	-	1	-	-	-	-
CO2	Apply	2	-	-	-	-	1	-	1	-	-
CO3	Analyse	1	-	-	-	-	1	-	1	-	-
CO4	Evaluate	1	1	1	2	1	1	-	1	2	2
CO5	Apply	2	2	1	3	1	2	1	1	3	3
	Average	**1.60**	**1.50**	**1.00**	**2.50**	**1.00**	**1.20**	**1.00**	**1.00**	**2.50**	**2.50**

Module 1 **(13 Hours)**

Units-Fundamental and derived physical units, Principal systems of units- Dimensions – Dimensional Formulae and equations- Uses of dimensional Equations- Limitations of dimensional analysis – SI unit-fundamental units

Reference

1. Chapter 1, Elements of Properties of matter: D. S. Mathur, 2000, 11th Edition, S. Chand and Co.

Module 2 **(15 Hours)**

Measuring instruments: Measurement of time - water clocks - sun dials - pendulum clocks - digital clocks - atomic clocks-Length measurements – Verniers- screw gauges - travelling microscopes - laser range finder - sonar - GPS- Angle Measurements - Spectrometer- measurement of stellar parallaxes- Electrical measurements - Working principle of galvanometer –conversion of galvanometer into voltmeter and ammeter- Basics of digital multimeter

Reference

1. Fundamentals of Physics; David Halliday & Robert Resnick; 2010; John Wiley & Sons

Module 3 **(10 Hours)**

Introduction to Energy Sources-Energy sources and their availability- Conventional energy sources- Renewable energy sources- Need of renewable energy sources

Reference

1. Non-conventional energy sources; G. D. Rai; 2011; Fifth Edition, Khanna Publishers

Module 4: Solar Energy **(18 Hours)**

Potential of Solar Energy-solar radiation and Measurement-types of solar energy collectors-Solar water heating systems- Solar air heating and cooling Systems-Solar thermal electric conversion- Solar Photovoltaic System-Other applications of solar energy like distillation, pumping, furnace, green house etc.

Reference

1. Non-conventional energy sources; G. D. Rai; 2011; Fifth Edition, Khanna Publishers
2. Non-conventional Energy Sources and Utilization (Energy Engineering); R. K. Rajput; 2012; 1st Edition.; S. Chand & Company Ltd.

CBRES101: SOLAR PV INSTALLATION: CIVIL AND MECHANICAL

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Study and apply various electrical parameters like current, voltage and resistance

CO2: Install the civil and mechanical Parts of a solar PV Module.

CO3: Study and understand basics of energy from sun and the different Factors affecting electricity generated by a solar PV module.

CO4: Design a solar PV system.

CO5: Identify the uses of tools and equipment used during solar PV installation and basics of measuring instruments power and energy.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	-	-	-	1	-	1	-	-	-	-
CO2	Apply	1	-	-	-	-	1	1	1	1	2
CO3	Understand	2	2	1	2	-	1	-	2	1	1
CO4	Apply	3	1	2	2	1	2	-	3	2	3
CO5	Understand	1	1	1	-	-	1	1	2	2	1
	Average	**1.75**	**1.33**	**1.33**	**1.67**	**1.00**	**1.20**	**1.00**	**2.00**	**1.50**	**1.75**

Module 1 **(17 Hours)**

Training code of conduct, job role and career opportunities (Self-study)

An introduction: Energy from the Sun-Ohm's law: Electric current, voltage and Resistance-Connection in series and Parallel-Measuring Instruments - Power and Energy

Textbook

1. Solar PV Installer (Suryamitra) Participant Handbook

Module 2 **(20 Hours)**

Earthing and lightning protection -Terms and Definitions-Sun path diagram and solar Radiation-Components of solar PV system-Types of solar PV systems-Technical parameters and performance of a solar PV panel

Factors affecting electricity generated by a solar PV module-Connection of modules in series and parallel – Bypass diode – Blocking diode - Charging and discharging of batteries-battery storage capacity-State of charge and depth of discharge

Textbooks

1. Solar PV Installer (Suryamitra) Participant Handbook
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013, PHI Learning Pvt

Module 3 **(22 Hours)**

Identification and uses of tools and equipment used for solar PV installation-The importance of accurate load and site assessment-Steps for conducting a load assessment- Steps for conducting a site assessment-Deriving a PV solution from customers' requirements

Design methodology for SPV system: Approximate design of standalone system – Load estimation – Sizing and choice of electronic components- Determining the battery size- Determine the PV Module size- Fuse wire and junction box selection.

Textbooks

1. Solar PV Installer (Suryamitra) Participant Handbook
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013 PHI Learning Pvt

Module 4: **(11 Hours)**

Prepare bill of materials- Procurement of the solar PV system components-verification of components on site

Textbook

1. Solar PV Installer (Suryamitra) Participant Handbook

Reference

1. Planning and installing photovoltaic systems-A guide for installers, architects and engineers; The German Energy Society; 2008, Second Edition; Earthscan, UK.

CBRES102: SOLAR PV INSTALLATION: OPERATION AND MAINTENANCE

Credit: 5 **Total: 70Hours**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Know different procedures for the installation of civil and mechanical parts of PV system

CO2: Students can do overall system inspection

CO3: Obtain knowledge of trouble shooting and maintenance of different components

CO4: Conduct customer orientation for a PV system.

CO5: Prepare to become an entrepreneur

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	3	-	3	2	-	3	-	3	2	-
CO2	Understand	2	1	2	1	-	2	-	3	-	-
CO3	Understand	1	1	3	1	-	2	-	3	-	-
CO4	Understand	-	-	1	1	-	2	-	3	1	-
CO5	Understand	-	-	1	-	-	-	1	2	2	1
	Average	**2.00**	**1.00**	**2.00**	**1.25**	**0.00**	**2.25**	**1**	**2.80**	**1.67**	**1.00**

Module 1 **(20 Hours)**

Installation of civil and mechanical parts of solar PV system: Get equipment foundation constructed – Installation of mounting system – Installation of PV module – Installation of battery bank stand and Inverter stand- Preparation for solar installation - Install electrical components - Install conduits and cables - Get the grounding system installed - Install Battery Bank-Tools and accessories required for PV system testing Lightening protection, earthing/grounding and surge protection.

Wires: Appropriate choice of wires – Basics of current conduction – Type of wires – Measurement of wire dimensions – Wire sizing – Junction box

Reference

1. Solar PV Installer (Suryamitra) Participant Handbook
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013, PHI Learning Pvt

Module 2 **(18 Hours)**

Overall system Inspection-Testing of Array-Wire and earthing continuity Tests-Testing of charge Controller-Testing of batteries- Battery capacity test- Battery fault detection –specific

gravity observation – Instruments used for Battery Maintenance - Start up the PV System- Unintentional Islanding - functionality tests

Reference

1. Solar PV Installer (Suryamitra) Participant Handbook
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013, PHI Learning Pvt

Module 3 **(17 Hours)**

Sample test and commission record Sheet-Tools required for Maintenance-Preventive maintenance of PV System-Trouble shooting and Maintenance-Establish and follow safe work Procedure-Use and maintain personal protective Equipment-Identification and mitigation of safety Hazards-Work health and safety at heights

Reference

1. Solar PV Installer (Suryamitra) Participant Handbook

Module 4 **(15 Hours)**

Customer orientation for a Solar PV system: Demonstrate working principle of the solar PV system- Documentation on the use of the system

Employability and Entrepreneurship Skills: Personal strength and value -Digital literacy- Money matters - Preparing for employment and self-employment - Understanding entrepreneurship - Preparing to be an entrepreneur

Reference

1. Solar PV Installer (Suryamitra) Participant Handbook

CBRES1P01: PRACTICAL SOLAR PV INSTALLATION, OPERATION AND MAINTENANCE

Credit: 8 **Total Hours: 224**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Familiarize with PV system components and the basic tools for PV module installation.

CO2: Understand installation, operation and maintenance involved in the solar PV sector as well as to introduce them to concepts of safety and documentation

CO3: Identify and distinguish experiments pertaining to different branches of physics

CO4: Analyse the process and outcomes of an experiment quantitatively and qualitatively

CO5: Draw inferences from analyses conducted

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	-	3	2	1	1	1	2	2	1
CO2	Understand	2	1	3	2	1	1	1	2	2	1
CO3	Analyse	2	1	3	1	-	1	1	2	2	-
CO4	Analyse	2	-	3	-	-	2	1	2	1	1
CO5	Analyse	2	1	3	2	-	-	1	2	1	1
	Average	**2.00**	**1.00**	**3.00**	**1.75**	**1.00**	**1.25**	**1.00**	**2.00**	**1.60**	**1.00**

1. Site survey for Installation
2. Assessment of customer’s PV system requirement
3. Procurement of solar PV system components
4. Installation of Civil and Mechanical part of solar PV power plant
5. Installation of Electrical components of solar PV system
6. Testing and commissioning of solar PV system
7. Maintenance solar PV system
8. Maintenance of work safety of solar PV system
9. Customer orientation for solar PV system
10. Inspection of Record sheet

Practical: Physics

1. Verification of Ohm's law
2. Travelling microscope
3. Spectrometer-Angle of prism
4. Digital Multimeter

Note: Few more experiments of the same or above standards can be added.

SEMESTER II

CBREG202: SEMICONDUCTOR PHYSICS

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the structure of an atom

CO2: Classify solids in terms of energy bands. Install the civil and mechanical Parts of a solar PV Module.

CO3: Describe the basic theory of semiconductor diode and zener diode and their working as a rectifier and voltage stabilizer respectively

CO4: Know the explanation of properties and different modes of operations of BJTs. Design a solar PV system

CO5: Explain the working of optoelectronic devices, different types of photodetectors and basic ideas of solar cell

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	-	-	-	-	-	-	-	-	-	-
CO2	Apply	1	-	1	1	-	-	1	-	1	1
CO3	Understand	-	-	-	-	-	-	1	-	-	-
CO4	Apply	1	-	2	1	-	-	1	-	1	-
CO5	Understand	-	-	1	1	-	-	1	-	1	1
	Average	**1.00**	-	**1.5**	**1.00**	-	**-**	1.00	**-**	1.00	1.00

Module 1 **(10 Hours)**

Electronics- Atomic structure-structure of elements-The Electron-Energy of an electron-valance electrons-free electrons

Bohr's atom model- Energy levels- Energy bands in solids - Classification of solids -metals insulators and semi-conductors

Reference

1. Principles of Electronics; V. K. Mehta; 2006, Tenth Edition; S. Chand & Co.

Module 2: **(16 Hours)**

Semiconductors- bonds in semiconductors-crystals- commonly used semiconductors - Effect of temperature on semiconductors - hole current -intrinsic semiconductor - extrinsic semiconductor - charge on n type and p type semiconductors - majority and minority carriers-pn junction - current flow in forward biased pn junction - VI characteristics of pn junction

-Important terms -limitations in the operating conditions of a pn junction

Reference

1. Principles of Electronics; V. K. Mehta; 2006, Tenth Edition; S. Chand & Co.

Module 3 **(18 Hours)**

Semiconductor diode and transistors: Semiconductor diode-crystal diode as a rectifier-resistance of a crystal diode- equivalent circuit of a crystal diode-half wave rectifiers and full wave rectifiers (Centre tap and bridge) - - nature of rectifier output-ripple Factor-Comparison of rectifiers- filter circuits- types of filter circuits - Voltage stabilization - zener diode- zener diode as voltage stabilizer.

Transistors-Bipolar junction transistors- naming of transistor terminals - transistor action transistor symbols - Common emitter, common base and common collector configurations-their characteristics.

Reference

1. Principles of Electronics; V. K. Mehta; 2006, Tenth Edition; S. Chand & Co.

Module 4: **(12 Hours)**

Opto-electronic devices- Radiation Sources- LED - Principle - characteristics (V-I and light-current) applications, advantages

Photodetectors: Introduction - classification of detectors - qualitative idea of each type - photodiode, phototransistor, PIN photodiode- opto-isolators, APD

Solar Cells: Principles- I-V Characteristics - Fill factor - Conversion efficiency (qualitative study)

Reference

1. Optoelectronic Engineering, S.N. Biswass, Dhanpat Rai Publications
2. Photonics Elements and Devices, V. V. Rampal , Wheeler Publishing Co
3. Semiconductor optoelectronic devices - Pallab Bhattacharya

Additional Reading

1. Basic Electronics-B.L.Theraja: S.Chand Co.
2. Elements of electronics- M.K. Bagde, S.P. Sngh and K. Singh (S. Chand and Co.)
3. Optoelectronics, Wilson and Hawkes
4. Optoelectronics, Jasprit Singh
5. Semiconductor Physics and Devices - Donald A Neamen, Tata McGraw-Hill
6. Semiconductor Physics and Optoelectronis, V. Rajendran et al, Vikas Publishing House

CBRES203: ROOFTOP SOLAR GRID ENGINEERING

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

- **CO1:** Explain the planning, sizing and regulatory parameters of grid connected solar photo voltaic system.
- **CO2:** Understand how to install a grid connected solar photo voltaic system.
- **CO3:** Explain the operation of a Solar PV system
- **CO4:** Test and verify rooftop PV plant.
- **CO5:** Acquire knowledge and skills needed to do their work safely and avoid creating hazards that could place themselves or others at risk

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	-	2	1	1	-	-	1	1	-	1
CO2	Understand	2	1	1	-	-	1	-	1	-	-
CO3	Understand	2	-	1	-	-	-	-	1	-	-
CO4	Apply	1	2	1	-	-	-	-	1	-	-
CO5	Understand	-	1	-	-	-	-	-	1	-	-
	Average	**1.66**	**1.50**	**1.00**	**1.00**	**-**	**1.00**	**1.00**	**1.00**	-	1.00

Module 1 **(20 Hours)**

Planning and sizing of Grid Connected Photovoltaic Systems: Introduction to grid connected PV systems - Components of grid connected solar PV systems – Configuration of grid connected solar PV systems – Sizing the inverter – Selecting and sizing of cables, PV array combiner, junction box and isolator switch - Lightening protection – Earthing/grounding and surge protection.

Regulatory parameters for interconnection and metering arrangement- Documents required for connecting the PV system to grid - Capacity of the rooftop Solar PV power plant- Confirmation of Inverters, panel protection devices to IEC standards or relevant Indian standards

Module 2 **(15 Hours)**

Installing, commissioning and operating of Grid-Connected Photovoltaic Systems: General installation notes – Example installation of grid connected PV systems – Breakdowns - Typical faults and maintenance - Troubleshooting

Safety of earthing and lightning protection-Single line diagram of a rooftop solar PV power plant- Operation of installed solar metering system- Import and export of energy

Module 3 **(20 Hours)**

Testing and verification of the inverter operation-anti islanding functionality and Overload-Operation of the disconnect protection/isolation Devices-Test, record and verify the power quality of rooftop PV power plant at the time of interconnection: harmonics, current, voltage etc.

Module 4 **(15 Hours)**

Test and verify power Factor-Test and verify the rooftop solar PV power plant for any phase Imbalance-Test and verify the rooftop solar PV power plant

Work safety of solar PV system: Corporate policies required for workplace safety – requirements for safe work environment – personal protection equipment – accepted practices for personal protection – Environmental Hazards associated with photovoltaic installations – electrical hazards – safe and proper use of required tools and equipment – risk control measures – approved methods for moving tools and equipment – Installation of appropriate signs and barricade – safe dismantle of power plant

Reference

1. Regulations for Net Metering Rooftop Solar PV Grid Interactive Systems, GUJARAT ELECTRICITY REGULATORY COMMISSION, 2017, Notification No. 5/2016
2. Off grid and decentralized Solar applications, Ministry of New and Renewable energy, Govt. of India
3. UPERC (Rooftop Solar PV grid interactive systems gross/Net metering) Regulation 2015, Uttar Pradesh Electricity Regulatory Commission
3. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013, PHI Learning Pvt
4. Planning and installing photovoltaic systems-A guide for installers, architects and engineers; The German Energy Society; 2008, Second Edition; Earthscan, UK.
5. Grid-connected Solar Electric Systems, The Earthscan Expert Handbook for Planning, Design and Installation, Geoff Stapleton and Susan Neill

CBRES204: ENERGY STORAGE SYSTEMS

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Know various energy storage methods

CO2: Explain Primary & Secondary Batteries

CO3: Acquire knowledge on electrical and magnetic storage systems

CO4: Get knowledge on Sensible heat storage

CO5: Understand the concepts of latent heat storage methods

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	-	1	-	1	1	-	2	-
CO2	Understand	1	1	1	-	-	-	1	-	1	-
CO3	Understand	1	1	-	1	-	-	1	-	1	-
CO4	Understand	1	1	-	1	-	-	-	-	1	-
CO5	Understand	1	1	-	1	-	-	1	-	1	-
	Average	**1.20**	**1.20**	**1.00**	**1.00**	**-**	**1.00**	**1.00**	**-**	**1.20**	**-**

Module 1: Energy Storage **(17 Hours)**

Introduction-Energy storage systems- mechanical energy storage- Pumped hydroelectric storage- Compressed air storage- Electrical storage- The lead acid battery- Chemical storage- Energy storage via hydrogen- via ammonia- reversible chemical reactions- thermal energy storage- sensible heat storage- water storage

Reference

1. Chapter 16, Non-conventional energy sources; G.D.Rai; 2011, Fifth Edition, Khanna Publishers

Module 2: Electrochemical, Electrical and Magnetic Energy Storage Systems(24 Hours)

Primary & Secondary Batteries- Solid-State and Molten Solvent Batteries- Lead acid batteries- Nickel Cadmium Batteries, Advanced Batteries-Superconducting Magnet Energy Storage (SMES) Systems- Capacitors-Super capacitor-Electrochemical Double Layer Capacitor (EDLC)

Reference

1. Handbook of batteries; David Linden& Thomas B. Reddy; 2002; Third Edition; McGraw-Hill Companies, Inc.
2. Energy Storage; Robert A. Huggins; 2010, Springer

Module 3: Sensible Heat Storage (SHS) (14 Hours)

Mediums for SHS- Stratified storage systems- Rock-bed storage systems- Thermal storage in buildings- Energy storage in aquifers

Reference

1. Solar Thermal Energy Storage; H.P. Garg, S.C. Mullick and A. K. Bhargava; 1985, Springer

Module 4: Latent Heat Thermal Energy Storage (LHTES) (15 Hours)

Basics of latent heat storage – heat of fusion – employment of latent heat storage system – Phase change materials – solid-solid transitions – solid-liquid transformations – selection of PCM

Reference

1. Chapter 3, Solar Thermal Energy Storage; H.P. Garg, S.C. Mullick and A. K. Bhargava; 1985, Springer

PRACTICAL

CBRES2P02: GRID TIED SOLAR PHOTOVOLTAIC SYSTEM AND BASIC ELECTRONICS PRACTICAL

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Build a foundation for understanding Solar PV system integration to the grid.

CO2: Analyse the current waveform for Linear & Nonlinear Loads

CO3: Analyse the impact of transmission line inductance on voltage & THD

CO4: Analyse the performance of grid synchronised Solar PV inverter

CO5: Understand the working of various electronic components and some of the applications

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	2	3	-	1	1	1	2	1
CO2	Analyse	1	-	2	1	-	1	-	1	-	1
CO3	Analyse	1	1	1	1	-	1	1		1	-
CO4	Analyse	3	2	2	3	-	1	-	-	1	-
CO5	Understand	3	3	3	2	-	1	1	-	1	2
	Average	**2.00**	**2.00**	**2.00**	**2.00**	**-**	**1.00**	**1.00**	**1.00**	**1.25**	**1.33**

Demonstration of the working of Grid tied Solar system

Observation of Current Waveform for Linear & Nonlinear Loads and Calculations

Impact of Transmission Line Inductance on Voltage Quality at PCC (point of common coupling)

Change in THD (Total Harmonic distortion) with Change in Transmission Line Inductance

Power Factor Correction using Capacitor Bank and its Impact on Power Quality at PCC

Grid Synchronization of Solar PV Inverter and its Performance Analysis

Zener Diode characteristics

PN Junction Diode

Half Wave rectifier

Full Wave Rectifier

LED Characteristics

PN junction Diode Characteristics

Note: Few more Experiments of the same or above standards can be added

HANDS ON TRAINING (HOT)

CBRES2HT: HANDS ON TRAINING

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the working of various electronic components used while doing the training program.

CO2: Get acquainted with different tools used in the industry

CO3: Enable to make the required on the spot decisions

CO4: Develop problem solving skills while dealing with the practical problems

CO5: Familiarize with the barriers and challenges they face at workplace.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	2	1	3	1	1	1	2	-
CO2	Analyse	-	-	1	-	3	1	1	1	2	-
CO3	Analyse	1	2	2	1	3	1	-	2	-	-
CO4	Analyse	1	1	2	2	3	1	1	3	1	-
CO5	Analyse	1	-	-	1	3	1	1	2	1	2
	Average	**1.00**	**1.33**	**1.75**	**1.25**	**3.00**	**1.00**	**1.00**	**1.80**	**1.50**	**2.00**

SEMESTER III

CBREG303: FUNDAMENTALS OF COMPUTERS

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Develops basic understanding of computers, hardware and software units of computer system and to compare and contrast various types of computers, Explain the purpose of CPU and how it works, Know about various types of software's and its applications.

CO2: Develops basic understanding of data processing in a computer system, describe how information is stored and retrieved from memory, develop a basic knowledge of peripheral devices

CO3: Understand the importance and application of computers in business.

CO4: Use Microsoft office, learn the basics of Word processing and Spreadsheets

CO5: Use PowerPoint, learn the basics of preparation of presentations

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	-	-	1	-	-	2	1	-	1	-
CO2	Understand	-	-	-	-	-	-	1	-	1	-
CO3	Understand	-	-	1	-	-	1	1	1	1	-
CO4	Apply	-	-	1	-	1	1	-	2	1	-
CO5	Apply	-	-	1	-	1	1	-	2	1	-
	Average	-	-	**1.00**	-	**1.00**	**1.25**	**1.00**	**1.66**	**1.00**	-

Module 1: Exploring the Computer **(12 Hours)**

Computer – definition - Computer users - Computer for individual users - Computer for organizations - Computer in society –Components of Computer - input unit - output unit - storage unit CPU- ALU - control unit - registers - computer hardware – System software - Application software- Computer systems - Types of Computer systems- Micro, Mini, Mainframe and Super Computers - Analog, Digital and Hybrid Computers - Business and Scientific Computer systems

Module 2: Data Processing and Peripheral Devices **(15 Hours)**

Computer data - Information – Data Processing - Data Storage and Data retrieval capabilities – storage devices - primary memory - RAM, ROM, PROM, EPROM, cache memory - secondary memory - magnetic tape, hard disk, Compact disks - Importance of computers in

business - Computer applications in various areas of business- Computer related jobs in business.

Peripheral devices : Input devices – keyboard, mouse, scanner - output devices – monitor - VDU, LCD, CRT - printers - Commonly used printers, High-quality printers, Thermal-wax printers, Dyesublimation printers, Plotters.

Module 3: Understanding MS Office (15 Hours)

Word Processing Basics - Opening and closing Documents - Text Creation and manipulation - Formatting the Text - Table Manipulation- Using spread sheet - Elements of Spread Sheet - Manipulation of Cells - Formulas and Function

Module 4: Making Small Presentations (14 Hours)

Using PowerPoint - Creation of Presentation - Preparation of Slides - Inserting Word Table or an Excel Worksheet - Adding Clip Art Pictures - Presentation of Slides - Slide Show

Reference

1. Computer and Common Sense-Roger Hunt and John Shelley
2. Using Micro Computers- Bright man and Dims dale
3. Introduction to Computers-Alexis Leon and Mathews Leon
4. Michael Miller, Absolute Beginner's guide to computer Basics, Fourth Edition, Pearson Education, 2007
5. Peter Norton, Introduction to computers, 2007, Sixth Edition Tata McGraw Hill
6. Manuals for MS DOS, MS Office, MS Windows, UNIX.
7. Office 2000/2003 Complete, BPB Publication.
8. Internet basic reference A to Z, by Falk B., BPB, Delhi
9. Operating Systems by Stallings, PHI.

CBREG304: THERMODYNAMICS AND FLUID MECHANICS

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: State Basic laws in thermodynamics; learn different thermodynamic processes and the working of a Carnot engine.

CO2: Apply work done in different thermodynamical process

CO3: Learn the various methods for the transmission of heat and to find coefficient of thermal conductivity for different systems.

CO4: Explain the basics of fluid mechanics and fluid properties like surface tension and viscosity and the methods to determine both.

CO5: Describe different types of fluid flow, orifices and venturimeter.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	-	1	1	-	1	-	-	1	-
CO2	Apply	-	-	2	-	-	1	-	-	1	-
CO3	Understand	1	-	1	1	-	1	-	-	1	-
CO4	Understand	-	-	1	-	-	1	-	-	-	-
CO5	Understand	-	-	1	-	-	1	-	2	-	-
	Average	**1.00**	**-**	**1.20**	**1.00**	**-**	**1.00**	**-**	**2.00**	**1.00**	**-**

Module 1 **(12 Hours)0**

Laws of thermodynamics: - First law of thermodynamics- second law of thermodynamics- claussius and kelvin Statement-Reversible and irreversible Process- Isothermal and adiabatic Process-Workdone during adiabatic and isothermal Expansion-Heat engine and efficiency- Carnots engine- Carnots cycle- efficiency- Difference between heat pump and refrigerator.

Reference

1. Thermodynamics- Zemansky and Dittmann (Tata McGraw-Hill)
2. Heat and Thermodynamics- Brijlal and Subrahmanyam (S. Chand &Co)

Module 2 **(15 Hours)**

Transmission of Heat:- Conduction – Convection – Radiation - Coefficient of Thermal conductivity - Rectilinear flow of heat through a rod - Searle's method-Lee’s method for metals -Lee's Disc method conductors - Radial flow of heat through spherical shell- Cylindrical flow of Heat- Thermal Conductivity of Glass- Heat flow through compound wall

Reference

1. Thermodynamics- Zemansky and Dittmann, Tata McGraw-Hill
2. Heat and Thermodynamics- Brijlal and Subrahmanyam, S. Chand &Co

Module 3 **(15 Hours)**

Fluid Mechanics:-Definition of Fluid-Distinction between solids & fluid and liquid & gas fluid Continuum-Mass Density-Specific Volume-Viscosity- Newton's law of viscosity- Newtonian and Non-Newtonian Fluids-Flow of Fluids-Steady & Unsteady Flow Uniform & Non-Uniform Flow- Laminar & Turbulent Flow-Compressible & Incompressible Flow- Determination of coefficient of viscosity by Poiseuilles method-determination of viscocity by Stockes Method-Surface tension- Definitions, units and dimensions

Reference

1. Fluid Mechanics and Fluid Power Engineering; D.S. Kumar; 1997, S. K. Kataria & Sons.
2. A Textbook of Fluid Mechanics and Hydraulic Machines; R.K. Bansal; 2005, Ninth Edition; Laxmi Prakashan.
3. Theory and Applications of Fluid Mechanics; K. Subramanya; 1993, First Edition; Tata McGraw Hill Publishing Company Ltd.

Module 4 **(14 Hours)**

Description of fluid flow- Definition of path line, streamline, streak line, stream tube, Acceleration of Fluid particle- Lagrange and Eulerian approaches- Derivation of Euler's Equation-Bernoulli's equation -Flow through Orifices; Classification-Hydraulic Co-efficient of an Orifice and relation between them - Venturi Meter (Basic idea only)

Reference

1. Fluid Mechanics and Fluid Power Engineering; D.S. Kumar; 1997, S. K. Kataria & Sons.
2. A Textbook of Fluid Mechanics and Hydraulic Machines; R.K. Bansal; 2005, Ninth Edition; Laxmi Prakashan.
3. Theory and Applications of Fluid Mechanics; K. Subramanya; 1993, First Edition; Tata McGraw Hill Publishing Company Ltd.

CBREG305: NOVEL ENERGY SOURCES

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the basics of hydrogen energy and its applications.

CO2: Know the principle and types of Fuel cells.

CO3: Develop an understanding of Electrochemical Energy Storage System

CO4: Get a thorough knowledge on ocean energy resources, Ocean Thermal Conversion Systems (OTECs), Wave Energy Conversion Systems and Tidal Power Plant and Conversion Systems

CO5: Discuss magneto hydrodynamics energy systems and other storage systems like capacitors, supercapacitors, SMES etc.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	1	2	2	-	1	-	-	-	-
CO2	Understand	2	-	2	2	-	1	-	-	-	-
CO3	Understand	2	-	2	2	-	1	-	-	1	-
CO4	Understand	3	1	2	2	-	1	-	-	1	-
CO5	Understand	3	-	2	2	-	1	-	-	1	-
	Average	**2.40**	**1.00**	**2.00**	**2.00**	**-**	**1.00**	**-**	**-**	**1.00**	**-**

Module 1 **(14 Hours)**

Hydrogen Energy: Basics of Hydrogen Energy - Production methods - Storage and transportation - Applications

Reference

1. Non-conventional energy sources; G. D. Rai; 2011, Fifth Edition, Khanna Publishers
2. Non-conventional Energy Sources and Utilization (Energy Engineering); R.K. Rajput; 2012, First Edition, S. Chand & Company Ltd.

Module 2 **(14 Hours)**

Fuel Cell: Principle of working -Basic thermodynamic and electrochemical principles - Classifications-Applications for power generations

Electrochemical Energy Storage System: Batteries - Types - Working principles - Role of carbon nanotubes in electrode

Reference

1. Non-conventional energy sources; G. D. Rai; 2011 Fifth Edition, Khanna Publishers

2. Non-conventional Energy Sources and Utilization (Energy Engineering); R.K. Rajput; 2012, First Edition, S. Chand & Company Ltd.

Module 3 **(14 Hours)**

Ocean Energy: Ocean energy- Lambert's law, resources - Ocean energy routes - Ocean thermal energy conversion-types (open, closed, hybrid(basics), thermoelectric(basics) Advantages and disadvantages-

Wave energy – advantages and disadvantages, energy and power, conversion machines

Tidal energy power plants-types, components, &power generation, Tidal energy conversion

Small Hydropower Potential-advantages and disadvantages, classifications (elementary only)

Reference

1. Non-conventional energy sources; G.D. Rai; 2011, Fifth Edition, Khanna Publishers
2. Non-conventional Energy Sources and Utilization (Energy Engineering); R.K. Rajput; 2012, First Edition, S. Chand & Company Ltd.

Module 4: **(14 Hours)**

Magneto hydrodynamic (MHD) energy conversion: Principle of operation - Classifications - Features of MHD Systems

Magnetic and Electric Storage System: Super conducting magnetic energy storage (SMES) systems - Capacitor and super capacitor-applications

Reference

1. Non-conventional energy sources; G. D. Rai; 2011, Fifth Edition, Khanna Publishers
2. Non-conventional Energy Sources and Utilization (Energy Engineering); R.K. Rajput; 2012, First Edition, S. Chand & Company Ltd.

CBRES305: SOLAR THERMAL TECHNOLOGY - I

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Obtain a basic understanding of sun, different solar radiations and measurement of those radiation

CO2: Describe the concepts of Flat Plate Collectors and derive its efficiency.

CO3: Explain the technical and physical principles of different solar collectors

CO4: Distinguish the various materials for solar concentrators.

CO5: Describe the applications of solar energy like - heating, cooling, desalination, drying, cooking etc.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	-	-	-	-	2	-		1	-
CO2	Apply	1	2	3	2	-	1	-	-	-	-
CO3	Understand	2	2	3	2	-	1	-	1	-	-
CO4	Understand	2	1	-	1	-	1	-	-	-	1
CO5	Understand	2	1	2	1	-	1	-	1	2	1
	Average	**1.80**	**1.50**	**2.67**	**1.50**	**-**	**1.20**	**-**	**1.00**	**1.50**	**1.00**

Module 1: Solar Radiation **(14 Hours)**

The sun as the source of radiation - Solar Constant - Spectral distribution of extraterrestrial radiation and its variation - Basic Earth Sun angles - Diffuse radiation- Availability of solar radiation - measurement of diffuse and direct radiation

Reference

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

Module 2: Flat Plate Collectors **(19 Hours)**

Liquid Flat Plate Collector- Materials for flat plate collector- Efficiency of flat plate collectors- Flat plate air heating collectors-Types and novel designs- Solar ponds

Reference

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

Module 3: Solar Concentrating Collectors **(19 Hours)**

Parameters characterizing solar concentrators - Classification of solar concentrators - Thermodynamic limits to concentration - Solar concentrator mountings - Performance analysis

of cylindrical parabolic collector - Compound parabolic collector - Point focusing solar concentrators - Materials for solar concentrators

Reference

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

Module 4: Solar Thermal Applications (18 Hours)

Solar water heater-Natural and forced circulation type - Solar cookers -Types-Solar Still- Solar drying of food-Basics- Types-Solar heating of buildings- active and passive-Solar cooling of buildings-refrigeration and air conditioning - Solar furnaces - Solar thermal energy storage

Reference

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

CBRES306: WIND ENERGY

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Discuss the history of wind energy, its current and future prospects.

CO2: Understand about various causes of wind, its measurement and distribution

CO3: Explain about aerodynamics of wind turbine, its power regulation

CO4: Describe about various turbines, wind energy conversion system components

CO5: Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	3	-	1		-	-	2	-	1	-
CO2	Understand	3	-	1	1	-	2	-	-	1	-
CO3	Understand	3	1	1	1	-	2	-	-	1	-
CO4	Understand	3	1	1	1	-	1	-	-	1	-
CO5	Understand	3	2	1	1	-	1	2	1	1	-
	Average	**3.00**	**1.33**	**1.00**	**1.00**	**-**	**1.50**	**2.00**	**1.00**	**1.00**	**-**

Module 1: Basics of Wind Energy Conversion **(25 Hours)**

History of wind energy, Current status and future Prospects, Wind Energy in India - Power available in the wind - Wind Turbine power and Torque characteristics -Types of rotors: Horizontal and Vertical axis wind turbine -Characteristics of wind rotor-Analysis of wind regimes- Local effects, wind shear, Turbulence and acceleration effects- Measurement of wind: Ecological indicator, Anemometers-wind direction-Wind speed statistics: Time and Frequency distribution, Mean wind speed and-distribution of wind velocity

Reference

1. Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006, Springer

Module 2: Aerodynamics of Wind Turbine **(15 Hours)**

Airfoil, lift and drag characteristics- Aerodynamic theories- Axial momentum theory - Power coefficient and tip speed ratio Characteristics-Rotor design and Performance Analysis-Power curve of wind turbine

Reference

1. Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006, Springer

Module 3: Wind Energy Conversion Systems **(20 Hours)**

Wind electric generators- Tower, rotor, gearbox, power regulation, safety mechanisms- Generator: Induction and synchronous Generator-Grid integration-offshore wind farm- Wind pumps- Wind driven piston pumps, limitations and performance analysis

Reference

1. Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006, Springer

Module 4 **(10 Hours)**

Wind Energy and Environment: Environmental benefits and problems of wind energy

Economics of wind energy: Factors influencing the wind energy economics- Site specific Parameters -machine parameters- energy market-incentives and exemptions - Life cycle cost analysis

Reference

1. Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006, Springer III-9

Additional Reading

1. Johnson GL. Wind Energy Systems, 2006, Electronic Edition, Prentice Hall Inc
2. Burton T. Sharpe D. Jenkins N. Bossanyi E. 2001, Wind Energy Handbook. John Wiley
3. Jha AR. Wind Turbine Technology, 2011, CRC Press, Taylor & Francis
4. Jain P. Wind Energy Engineering, 2011, McGraw-Hill

CBRES3P03: THERMODYNAMICS AND SOLAR THERMAL

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Investigate and experiment with basic thermodynamic concepts and solar thermal application in the laboratory

CO2: Familiarize with thermodynamic aspects of various materials

CO3: Use various equipments used for measuring solar radiation and to provide hands on experience in operation of solar water heaters.

CO4: Apply the experimental knowledge how to perform the experiments in different manner.

CO5: Predict the sources of errors and minimizing them in the experiments.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Analyze	2	-	1	1	-	2	-	-	-	-
CO2	Understand	1	-	1	1	-	2	-	-	-	-
CO3	Understand	2	-	2	1	-	2	-	-	1	-
CO4	Apply	2	-	1	1	-	2	-	-	1	-
CO5	Apply	-	-	1	1	-	2	-	-	-	-
	Average	**1.75**	**-**	**1.20**	**1.00**	**-**	**2.00**	**-**	**-**	**1.00**	**-**

1. Thermal conductivity of bad solid conductor- Lee's Disc
2. Thermal conductivity of powder samples- Lee's Disc
3. Thermal conductivity of rubber
4. Specific latent heat of steam-using condenser
5. Specific heat of liquid -Newton's law of cooling
6. Specific heat capacity of a solid
7. Operational experience on Pyranometer
8. Familiarization of Sunshine recorder
9. Measurement of temperature using Infrared Thermometer and Thermocouple
10. Evaluation of different parameters of Flat-Plate Collector in thermosyphonic mode of flow with fixed input parameters
11. Evaluation of different parameters of Flat-Plate Collector in thermosyphonic mode of flow with different radiation level
12. Evaluation of different parameters of Flat-Plate Collector in thermosyphonic mode of flow with different inlet water temperature

Note: Few more Experiments of the same or above standards can be added

CBRES3P04: FLUID DYNAMICS AND WIND ENERGY

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the procedure to conduct experiments related to fluid mechanics devices and components using different measurement systems and equipments.

CO2: Interpret various parameters influence the performance of the fluid mechanics devices and components.

CO3: Analyze the observations made through experiments.

CO4: Apply the experimental knowledge how to perform the experiments in different manner.

CO5: Predicting the sources of errors and minimizing them in the experiments.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	-	-	1	-	2	-	-	1	-
CO2	Analyze	-	-	1	1	-	2	-	-	1	-
CO3	Analyze	1	-	-	1	-	2	-	-	1	-
CO4	Apply	1	-	-	1	1	2	-	-	1	-
CO5	Apply	-	-	-	1	1	2	-	-	1	-
	Average	**1.00**	**-**	**1.00**	**1.00**	**1.00**	**2.00**	**-**	**-**	1.00	-

1. Surface tension - Capillary rise method
2. Density of a liquid – Constant Pressure Head Method
3. Measurement of wind speed
4. Evaluation of cut-in speed and cut-off speed
5. I-V characteristics of wind turbine at different wind speed
6. Characteristics of wind turbine with electrolysis and water pump
7. P, V and F measurement of output of wind generator
8. Efficiency of charge controller
9. Determination of Tip Speed Ratio
10. Demonstration of system with charge controller
11. Demonstration of system with charge controller and inverter
12. Power quality of AC output of system.
13. Impact of wind speed on power output and its quality
14. Impact of load on power output and its quality
15. Density of a liquid – Variable Pressure Head Method
16. Density of a liquid – Stokes Method

Note: Few more Experiments of the same or above standards can be added

SEMESTER IV

CBREG406: ANALYSIS OF A SOLAR THERMAL SYSTEM

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the Concepts and Definitions of Overall Heat Transfer.

CO2: Discuss the basic concepts and laws of radiation

CO3: Describe the types and parts of Flat-Plate Collectors and discuss the different methods for the Testing of Collector.

CO4: Explain the working of different types of Evacuated-Tube Cover Collector.

CO5: Understand and conduct the procedure to do the Economic analysis of solar PV Systems.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	1	2	-	1	1	-	1	1
CO2	Understand	2	2	1	2	-	1	1	1		1
CO3	Understand	1	2	1	1	1		1		1	1
CO4	Understand	1	1	2	2		1	1	1	1	1
CO5	Apply	3	2	-	1	1	3	-	1	1	1
	Average	**1.80**	**1.80**	**1.25**	**1.60**	**1.00**	**1.50**	**1.00**	**1.00**	**1.00**	**1.00**

Module 1: Heat Transfer: Concepts and Definitions (18 Hours)

Introduction-Conduction-Fourier's law-Thermal conductivity- differential equation of conduction- Boundary Conditions-Overall Heat Transfer-single and parallel slabs-parallel slabs with air cavity- Heat transfer in parallel paths- Coaxial cylinders- Concentric spheres-Dimensionless Heat Conduction Parameters-Convection- Dimensionless Heat Convection Parameters-Bulk temperature-Radiation- Radiation involving real surfaces- Kirchoff's law of thermal radiation- laws of thermal radiation- heat and mass tranfer

Reference

1. Chapter 2, Solar Energy: Fundamentals, Design, Modeling and Applications; G. N. Tiwari; 2002, Alpha Science.

Module 2: Flat-Plate Collectors: Performance and Testing (12 Hours)

Introduction- Flat-Plate Collectors-Glazing material- Evacuated tubular Collectors-types of flat plate collectors- -Testing of Collector- Orientable test Rig- Series connected test Rig- Testing

of solar Collector with intermittent output-Heat Transfer Coefficients- Fin Efficiency (basic idea only)- Optimum inclination of flat plate collector- Effect of dust in flat plate collector

Reference

1. Chapter 3, Solar Energy: Fundamentals, Design, Modeling and Applications; G. N. Tiwari; 2002, Alpha Science.

Module 3: Evacuated Solar Collector (10 Hours)

Introduction-Evacuated-Tube Cover Collector- solaron collector- Philips (Germany collector)- Thermal efficiency- Analysis of owens-illinois(OI) Collector- Evacuated tube Collector with Heat Pipe- Corning collector with internal reflector- Gumman Evacuated-Tube Collector – Thermal analysis

Reference

1. Chapter 4, Solar Energy: Fundamentals, Design, Modeling and Applications; G. N. Tiwari; 2002, Alpha Science.

Module 4: Economic Analysis (16 Hours)

Initial and Annual Costs-Definitions-Present Worth Calculation-Repayment of loan in equal annual Installments-Annual Savings-Cumulative Savings and Life Cycle Savings-Economic analysis of add-on solar Systems-Payback Period-Clean development mechanism.

Reference

1. Solar Energy: Principles of Thermal Collection and Storage; S. P. Sukhatme and J. K. Nayak; 2008, Tata McGraw-Hill.

CBREG407: MATERIALS FOR GREEN ENERGY

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Know basic and detailed knowledge on nanoscience and nanomaterials

CO2: Explain different characterization methods and electrical and optical properties of nanomaterials

CO3: Explain in detail the various applications of nanomaterials

CO4: Discuss different preparation methods and applications of various polymers

CO5: Get a detailed knowledge on different thin film fabrication methods

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	2	1	-	3	2	1	1	2
CO2	Understand	3	2	3	2	1	3	3	1	2	1
CO3	Understand	1	1	1	1	1	1	1	2	1	1
CO4	Understand	1	1	1	1	-	1	1	1	2	2
CO5	Understand	2	1	2	2	-	2	1	-	2	3
	Average	**1.80**	**1.40**	**1.80**	**1.40**	**1.00**	**2.00**	**1.60**	**1.25**	**1.60**	**1.80**

Module 1 **(16 Hours)**

Classification of nanomaterials, properties of nanomaterials, applications, synthesis of nanomaterials: bottom-up synthesis, top-down synthesis

Different forms of nano materials in solar cells (performance analysis only): nanowires, nanotubes, nanocones, nanopillars, nanobelts, nanopagodas, nanocombs, nanorods,

Sustainable energy application: nanomaterials applied to solar cells: Thermodynamics of solar energy and operational principle of solar PV, Crystalline Silicon PV, Organic PV, Dye-sensitized Solar PV

Sustainable energy application: nanomaterials applied to fuel cells- proton exchange fuel cell, and solid oxide fuel cell, catalyst degradation

Reference

1. Nano materials for sustainable energy, ed. Quan Li, Spri+nger, 2016, ISBN 978 3319320212
2. Advanced nanomaterials and their applications in renewable energy, Jingbo Louise, Liu and Sajid Bashir, Elsevier, ISBN 9780128015285
3. Handbook of Nanoelectrochemistry, ed. Editors: Mahmood Aliofkhazraei, Abdel Salam Hamdy Makhlouf, 2015, Springer, Switzerland

Module 2 **(16 Hours)**

Nano structured materials for high efficiency Perovskite solar cells: nanostructured scaffold layers in PSCs-TiO2 layers, Al2O3 layers, ZnO layers, NiO layers, Carbon materials and other structured layers

Dielectric nanomaterials in today's and future silicon solar cells, Types of dielectric nanomaterials for silicon solar cells, dielectric materials and light management

Mechanism and material requirement for solar water splitting, Nano material for hydrogen generation from solar water splitting, Nano materials for the production of bio fuels (basics only), Nanomaterials for organic and inorganic solar cells (performance analysis only)

Reference

1. Nano materials for sustainable energy, ed. Quan Li, Springer, 2016, ISBN 978 3319320212
2. Advanced nanomaterials and their applications in renewable energy, Jingbo Louise, Liu and Sajid Bashir, Elsevier, ISBN 9780128015285
3. Handbook of Nanoelectrochemistry, ed. Editors: Mahmood Aliofkhazraei, Abdel Salam Hamdy Makhlouf, 2015, Springer, Switzerland

Module 3: Natural and Synthetic Polymers **(16 Hours)**

Classification of polymers: Natural, synthetic; linear, cross-linked and network; plastics, elastomers, fibres; homopolymers and copolymers. Polymerization reactions, typical examples- polyethene, polypropylene, PVC, polyester. Natural rubber: structure, vulcanization. Synthetic rubbers- SBR, nitrile rubber, neoprene.

Basic concepts in polymer solar cells: double layer cells, bulk heterojunction cells, Technologies for hybrid solar cell fabrication, coating and printing techniques: casting, spin coating, screen coating on single substrate, ink jet printing, roll to roll techniques, slot die coating

Reference

1. Polymer Science, V. R. Gowariker, 2010, NewAge International.
2. Text book of polymer science, Billmeyer F.W., 1994, Jr.John Wiley and Sons.
3. Advanced Solar cell, materials, technology, modeling and simulation, Laurentiu Fara and Masafumi Yamaguchi, 2013, Engineering Science Reference, IGI Global

Module 4: Thin Film Fabrication Methods **(8 Hours)**

Physical Methods-Vacuum Evaporation-Electron Beam Evaporation-Flash Evaporation-different types of Sputtering-Chemical Methods-Electro deposition-electro Plating-Chemical Bath-Spray Pyrolysis.

Reference

1. Thin film Phenomena; K L Chopra; 1969; McGraw Hill.
2. Handbook of Thin film technology; L. I. Meissel& R. Glang; 1970; McGraw Hill.

CBREG408: ENVIRONMENTAL EDUCATION

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the scope and objectives of environmental education

CO2: Develop an understanding of environmental pollutions and hazards due to engineering/technological activities

CO3: Develop an understanding of general measures to control them

CO4: Aware of important acts and laws in respect of environment.

CO5: Discuss about the international effort for environmental protection

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	2	1	-	3	3	1	2	2
CO2	Understand	3	1	1	-	-	3	3	1	1	3
CO3	Understand	1	1	1	-	1	1	3	1	2	1
CO4	Understand	1	1	1	-	-	3	2	1	1	1
CO5	Understand	2	1	1	-	-	2	2	1	1	1
	Average	**1.80**	**1.20**	**1.20**	**1.00**	**1.00**	**2.40**	**2.60**	**1.00**	**1.40**	**1.60**

Module 1: Objectives, Scope and Nature of Environmental Education (15 Hours)

Meaning, definition and characteristics of environmental education – content; Importance, objectives and scope of environmental education; Factors of degradation of environment – impacts of degradation of environment. Environmental education at school level. National resource center for environmental education. Impact of Science and technology on environment – resources-degradation of resources – Role of individual in conservation of natural resources- Role of information technology in environmental and human health.

Reference

1. Sharma, R. A., Environmental Education. Meerut, 2008, R.Lall Books Depot.
2. Sharma, B. L., & Maheswari, B. K., Education for Environmental and Human value, 2008 Meerut: R.Lall Books Depot.
3. Singh,Y. K., Teaching of environmental science. 2009, New Delhi: APH Publishing Corporation.
4. Sharma, V. S., Environmental education. New Delhi, 2005, Anmol publication.
5. Reddy, P. K., & Reddy, N. D., Environmental Education. Hyerabad, 2001, Neelkamal publications.
6. Kelu, P., Environmental education: A conceptual analysis. Calicut, 2001, Calicut University.

7. Joy, P., & Neal, P., The handbook of environmental education: London, 1994, New Fetter Lane
8. Sharma, R. G. Environmental Education. New Delhi, 1986, Metropolitan Book Co., Pvt. Ltd.

Module 2: Environmental Pollution, Management and Protection (15 Hours)

Meaning and definition of Environmental hazards and pollution – Types of environmental hazards and disaster – Types of pollution: Land, Air, Water, Soil, Marine, Noise, and Radiation- Green house effect- Ozone layer depletion.Global Warming-Environmental management- Factors responsible for flora and fauna extinction – Measures to conserve flora and fauna.- causes for forest fire- measures of prevention

Reference

1. Harrison R.M., Pollution: Causes, Effects and Control, 1993, Royal Society of Chemistry.
2. Marquata K. Hill., Understanding Environmental pollution, 1997, Cambridge University Press. IV-6

Module 3: India and Environmental Issues, Policies and Movements (15 Hours)

Major environmental problems in India – Environmental protection and polices inIndia – Need and objectives of conservation – Environmental conservation measures taken in India– Constitutional amendments made and Environmental laws. Environmental movements in India.

Reference

1. Kumar, A., A text book of environmental science. New Delhi, 2009, APH Publishing Corporation.
2. Singh,Y. K., Teaching of environmental science. New Delhi, 2009, APH Publishing Corporation.
3. Sharma, V. S., Environmental education. New Delhi, 2005, Anmol publication.
4. Reddy, P. K., & Reddy, N. D., Environmental Education. Hyerabad, 2001, Neelkamal publications.

Module 4: International Efforts for Environmental Protection (15 Hours)

The Stockholm conference 1972 – Brundtland commission 1983 – Nairobi conference 1982 – The Rio Summit 1992 – the Rio Declaration at the earth charter – Major achievements of the Rio Summit – Main features of the Rio Declaration – Kyoto conference and part on Global Warming 1997.

Reference

1. Ian Paulford., Hugh Flowers., Environmental Chemistry at a Glance, 2006, Blackwell.
2. Marquata K. Hill., Understanding Environmental pollution, 1997, Cambridge University Press.
3. Harrison R.M., Pollution: Causes, Effects and Control, 1993, Royal Society of Chemistry.
4. Jogdand S.N., Environmental biotechnology and industrial pollution management, 1995, Himalaya Publishing House

CBRES407: SOLAR PHOTOVOLTAIC ENERGY CONVERSION - I

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Knowledge about solar cell fundamentals, generation of electricity from solar cell

CO2: Thorough understanding of various solar cell parameters, its performance analysis

CO3: Idea about various technology use for the production of solar cell, various solar cell classification

CO4: Knowledge about panels, array, module and their connections and different specifications according to the requirement

CO5: Understand the fabrication and manufacturing process involving the panels

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	3	3	2	1	3	2	3	2	2
CO2	Apply	3	3	3	2	1	3	2	2	2	1
CO3	Understand	3	2	3	2	-	3	2	1	2	2
CO4	Understand	3	3	2	2	-	3	2	2	2	1
CO5	Apply	3	3	2	2	1	3	2	2	2	1
	Average	**2.80**	**2.80**	**2.60**	**2.00**	**1.00**	**3.00**	**2.00**	**2.00**	**2.00**	**1.40**

Module 1: Solar Cell Fundamentals **(13 Hours)**

Introduction- semiconductors- p-n junction- generation of electron-hole pair by photon absorption- photoconduction

Reference

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

Module 2: Solar Cell Characteristics **(17 Hours)**

I-V characteristics- solar cell parameters- open circuit voltage, short circuit current, fill factor, efficiency- effect of variation of insolation and temperature- energy losses and efficiency- maximizing the performances- cell size- Energy Payback Period (EPP)

Reference

1. Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki; 2011, Prentice Hall of India.

2. Solar Energy: Fundamentals and Applications; H. P. Garg & J. Prakash; 2000, Tata McGraw-Hill.
3. Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus; 2003, John Wiley and Sons.

Module 3: Classification of Solar Cells (20 Hours)

On the basis of thickness of active material- On the basis of Junction structure- On the basis of type of active material- single crystal silicon solar cell- multicrystalline silicon solar cell- gallium arsenide solar cell- amorphous silicon solar cell- copper sulfide, cadmium telluride and copper indium selenide based solar cell- Dye Sensitised Solar Cells (DSSCs)- Polymer solar cells

Reference

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

Module 4: Solar Photovoltaic (PV) Module, Panel and Array Construction (20 Hours)

Solar PV modules- solar PV modules from solar cells, series and parallel connection, mismatch in cell/module, design and structure of PV modules, number of cells in a module, Wattage of modules, fabrication of PV modules, rating of PV modules- construction of solar PV panels and arrays from modules

Reference

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

CBRES408: ENTREPRENEURSHIP IN SOLAR PV

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Assess the quality of solar module.

CO2: Familiarize with charge controllers, MPPT, inverters.

CO3: Evaluate the cost benefits and installing conditions of PV module.

CO4: Estimate capacity and risks associated with solar project.

CO5: Understand the regulatory requirements and entrepreneur skills for solar project.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	3	2	3	2	1	2	2	1	1	2
CO2	Understand	2	2	3	2	1	2	1	1	2	2
CO3	Understand	1	1	1	-	1	2	2	2	1	1
CO4	Understand	1	1	1	1	1	2	2	2	2	1
CO5	Understand	1	1	1	1	-	1	2	1	2	1
	Average	**1.60**	**1.40**	**1.80**	**1.50**	**1.00**	**1.80**	**1.80**	**1.40**	**1.60**	**1.40**

Module 1 **(15 Hours)**

Assessment of the quality of solar module - Identifying the key technical parameters of solar module - Selection of right quality of the inverter, battery, balance of the system by identifying the respective the technical parameters

Charge controller, MPPT and Inverters: Power converters and their efficiency, AC to DC converters – Types of inverters – Inverter specifications – DC to DC Power converters – Charge controllers – Typical specification of charge controllers- Maximum power point tracking

Module 2 **(15 Hours)**

Identification of the market price of the components - Prepare an estimate for the cost of a solar project - Cost benefit analysis for a rooftop solar PV plant including LCOE, Payback, IRR etc. - Identification of the policy, regulations and procedures for Solar rooftop sector – The appropriate business models - Identification of optimum location of installations - Asses the site level pre-requisites for Solar panel installation -Deciding the type and place of mounting of Panel-Checking of shading Obstacles-Preparation of site map of the Location-Asses the load to be run on solar PV plant - Preparation of load profile

Module 3 **(20 Hours)**

Estimation of the capacity of solar PV power plant - Decide on battery backup -Asses or obtain major parameters; GHI, DNI, Temperature and wind – Performance of shading analysis- Estimate the energy generated from rooftop solar PV power plant using softwares like

PV*SOL, PVsyst, etc. – Identification of the risk associated with solar project – Preparation of a site feasibility study report using softwares - Read and interpret the single line diagram and Civil/Mechanical/Electrical drawings - Read and interpret the bill of material – Calculation of the life cycle cost of a rooftop solar project - Identify and mitigate various risks associated the project

Module 4 **(20 Hours)**

The regulatory requirements of local government for solar PV system and structure – Preparation of action plan and implementation of rooftop solar project - Coordinate with the supplier for timely delivery of components - Prepare a draft project activity implementation plan - Coordinate with supervisor for the timely implementation of project - Identify the maintenance activities required for a solar PV plant – Preparation of preventive maintenance schedule - Regulation inspection of the solar PV system and rectification of the faults

Entrepreneurship skills: The process of setting up a new venture – the key ingredients of a business plan – fixed and working capital requirements – components of loan application for fund raising - Identify the characteristics of Entrepreneur - Good Etiquettes and manners required to communicate with client - The importance of time management — Leadership skills and effective resource management skills - The use of MS word and MS Excel for preparing business Proposal - Preparation of a workable presentation of marketing and business devolopment - choose right byer –Identification of the challenges and risks for a new Entrepreneur - Identify corporate policies required for workplace safety – The occupational health and safety standards and regulations for installation of solar PV system

Reference

1. Training Manual for Engineers on Solar PV System, Prof. Dinesh Kumar Sharma, Government of Nepal Ministry of Environment, Science and Technology
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, 2013, PHI Learning Pvt
3. Entprenership, Cynthia L Greene, South Western Cengage Learning

CBRES4P05: SOLAR PHOTOVOLTAICS

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Apply necessary steps to conduct market research, site feasibility, lifecycle cost and prepare cost estimate for a rooftop solar photovoltaic plant

CO2: Evaluate temeperature dependence of semiconductor

CO3: Analyse I-V characteristics of a solar cell-Calculation of Fill Factor and Efficiency

CO4: Comparison of the illuminated I-V characteristics of a photodiode with that of a solar cell

CO5: Study the Thermistor characteristics and evaluate bandgap Energy of Semiconductor Diode

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	1	1	3	-	1	1	1	1	2
CO2	Apply	1	-	1	3	-	1	1	1	1	2
CO3	Apply	2	-	1	3	-	1	1	1	1	2
CO4	Apply	2	-	1	3	-	1	1	1	1	2
CO5	Apply	2	-	1	3	-	1	1	1	1	2
	Average	**1.80**	**1.00**	**1.00**	**3.00**	**-**	**1.00**	**1.00**	**1.00**	**1.00**	**2.00**

1. Carry out Market research and prepare a cost estimate for a rooftop solar Photovoltaic Plant
2. Prepare a site feasibility study report
3. Calculate the lifecycle cost of a roof top solar project using software like Excel, PV*SOL, PVsyst etc.
4. Temperature dependent conductivity of semiconductor.
5. Lux meter and Power meter familiarization.
6. Illuminated I-V characteristics of a solar cell-Calculation of Fill Factor and Efficiency.
7. Comparison of the illuminated I-V characteristics of a photodiode with that of a solar cell.
8. Battery charging and discharging characteristics.
9. Combine AC and DC load system with battery.
10. Thermistor
11. Bandgap Energy of Semiconductor Diode

Note: Few more Experiments of the same or above standards can be added

ON JOB TRAINING (OJT)

CBRES4OJT: ON JOB TRAINING

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Expose to obstacles and challenges encountered during the jobs related to Renewable Energy Management

CO2: Acquire the practical based skills of design, development in the industry

CO3: Apply the theoretical knowledge to the sector and draw valid inferences

CO4: Understand the way of effective communication while handling different projects

CO5: Enable to work with other people and develop inter personal dynamics

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	3	-	3	1	2	2	1	-
CO2	Analyse	1	1	3	2	3	1	2	-	1	-
CO3	Analyse	3	2	3	2	3	1	2	1	-	-
CO4	Analyse	1	-	-	-	3	1	-	2	-	-
CO5	Analyse	1	-	-	-	3	1	1	2	2	2
	Average	**1.40**	**1.33**	**3.00**	**2.00**	**3.00**	**1.00**	**1.75**	**1.75**	**1.33**	**2.00**

SEMESTER V

CBREG509: LASERS AND OPTICAL INSTRUMENTATION

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Know the working principle of Lasers

CO2: Understand different structure and types of lasers in detail

CO3: Understand applications of lasers in various fields

CO4: Know the principle associated with fibre optics and fibre optic communication

CO5: Get a thorough knowledge of different optical components and their characteristics

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	1		3	-	-	3	3	2	1	-
CO2	Understand	-	1	3	-	-	3	3	2	2	1
CO3	Understand	-	1	2	-	-	3	3	1	2	2
CO4	Apply	1		1	-	-	3	3	1	3	1
CO5	Apply	1	1	1	-	-	3	2	1	3	1
	Average	**1.00**	**1.00**	**2.00**	**-**	**-**	**3.00**	**2.80**	**1.40**	**2.20**	**1.25**

Module 1: Lasers **(14 Hours)**

Absorption and emission of light-Absorption-spontaneous emission and stimulated emission-light amplification by stimulated emission-Einstein's relations-condition for light amplification -population inversion-pumping-pumping methods -optical pumping - electrical pumping - direct conversion. Active medium-metastable states-pumping schemes (two level, three level and four level) Optical resonator (theory not required) Threshold condition. Types of lasers-ruby laser, Nd-YAG laser, He-Ne laser, semi-conductor laser-High Power Laser

Reference

1. An introduction to lasers theory and applications; M N Avadhanulu; 2012, S. Chand& Co
2. Introduction to lasers and Applications; D.C. O'shea and W. R. Callen; 1978, Addision Wesley.

Module 2: Applications of Lasers **(14 Hours)**

Laser for measurement of distance, length, atmospheric effect and pollutants-material processing-laser heating, melting, scribing, trimming, welding, material removal and vaporization-Calculation of power requirements of laser for material processing-Holography-Basic principles-types -Medical application of lasers.

Reference

1. An introduction to lasers theory and applications; M N Avadhanulu; 2012, S. Chand & Co
2. Introduction to lasers and Applications; D.C. O'shea and W. R. Callen; 1978, Addision Wesley.

Module 3: Fibre Optics and Optical Communication (14 Hours)

Optical fibre- Critical angle of propagation-modes of propagation- Acceptance angle- Fractional refractive index change- Numerical Aperture- Types of Optical fibers- Fibre optic communication system- Advantages of Optical fibers.

Reference

1. A textbook of optics; N. Subramanayam, Brijlal and M. N. Avadhanalu; 2004, S.Chand& Co.

Module 4: Optical Components and Their Characteristics (14 Hours)

Plane mirrors, curved mirrors, achromatic prisms, direct vision prisms, right angle prisms, roof prisms, erecting prisms, cube corner prisms, beam splitter prisms, lenses, and ophthalmic lenses. Optical materials and fabrication techniques: optical glasses and their characteristics, crystalline materials.

Reference

1. Optics and optical instruments, Johnson, Dover.

CBREG510: ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Learn the safety acts, regulations and initiatives.

CO2: Understand the insights of hazards and control measures

CO3: Study the work place safety and safety systems.

CO4: Understand the procedure for preparation of Emergency Plans and Accident investigation

CO5: Learn the importance of education and training on safety management.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	3	-	-	2	3	1	1	1
CO2	Understand	1	1	3	-	-	2	2	1	1	1
CO3	Understand	1	1	3	-	-	2	1	1	1	-
CO4	Understand	-	1	3	1	-	2	2	1	-	1
CO5	Understand	-	1	3	1	-	2	1	1	-	-
	Average	**1.00**	**1.00**	**3.00**	**1.00**	**-**	**2.00**	**1.80**	**1.00**	**1.00**	**1.00**

Module 1: Occupational Health and Hygiene **(15 Hours)**

Need for developing Environment, Health and Safety systems in work places.

The Hierarchy of Safety, Health, and Environmental Management.

Understanding OSHA and Safety and Health Regulations, OSHA ACT

The Basics of Managing Safety, Health, and Environmental Programs.

Ergonomics and work place. Categories of health hazards. Exposure pathways and human responses to hazardous and toxic substances. Advantages and limitations of environmental monitoring and occupational exposure limits. Hierarchy of control measures for occupational health risks. Role of personal protective equipment and the selection criteria. Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress.

Reference

1. Jogdand S.N., Environmental biotechnology and industrial pollution management, 1995, Himalaya Publishing House.
2. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, 2005, Culinary and Hospitality Industry Publications Services
3. Kumar R. (Editor), Environmental pollution and health hazards in India, 1997, Ashish Publication.

4. Ghosh G.K., Environmental pollution: a scientific dimension, 1987, Ashish Publication.

Module 2: Workplace Safety and Safety Systems (15 Hours)

Features of the satisfactory design of work premises HVAC. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Requirements for the safe use of display screen equipment. Contingency arrangements for events of serious and imminent danger.

Reference

1. Jogdand S.N., Environmental biotechnology and industrial pollution management, 1995., Himalaya Publishing House.
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, 1995, William Andrew Inc. NY.
3. Ian Paulford., Hugh Flowers., 2006, Environmental Chemistry at a Glance. Blackwell.
4. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant.

Module 3: (16 Hours)

Techniques of Environmental Safety-Elements of a health and safety policy and methods of its effective implementation and review.Functions and techniques of risk assessment, inspections and audits .Investigation of accidents- Principles of quality management systems in health and safety management. Relationship between quality manuals, safety policies and written risk assessments. Records and other documentation required by an organization for health and safety

Reference

1. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, 1995, William Andrew Inc. NY
2. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, 2007, Government Inst Publ.
3. Khitoliya R.K., Environmental pollution management and control for sustainable development, 2004, S. Chand publication.
4. Bhattiya S.C., Managing industrial pollution, 2003, Mc Millan India Ltd.
5. Trivedi R.K. (Editor), Pollution and Bio monitoring of Indian Rivers. ABD publication.

Module 4: Education and Training (10 Hours)

Requirements for and benefits of the provision of information, instruction, training and supervision. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

Reference

1. Reddy, P. K., & Reddy, N. D., Environmental Education. 2001, Hyerabad: Neelkamal publications.
2. Kelu, P., Environmental education: A conceptual analysis, 2000, Calicut: Calicut University.
3. Agarwal, S.P. and Aggarwal, J.C., Environmental Protection, Education and Development, 1996, New Delhi: New Concepts.

CBREG511: PROJECT MANAGEMENT

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Study about project types, project life cycles and project planning.

CO2: Familiarize project implementation and monitoring methods.

CO3: Understand project team management processes.

CO4: Know the basic concepts and structure on project organization and its legal aspects

CO5: Understand project termination, project inventory management.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	3	1	1	-	2	1	2		1
CO2	Understand	-	3	1	1	-	2	1	1	1	-
CO3	Understand	1	3	1	1	-	2	1	1	1	-
CO4	Understand	-	3	1	1	-	1	1	-	2	1
CO5	Understand	-	3	1	1	-	1	1	-	1	1
	Average	**1.00**	**3.00**	**1.00**	**1.00**	**-**	**1.60**	**1.00**	**1.33**	**1.25**	**1.00**

Module 1 **(13 Hours)**

Project Management

Introduction-Definitions-Different Types of Projects-Project Life Cycles and Life Histories Factors for Project Success or Failure

Project Planning: Definition- Problem Statement- Project Goals- Objectives- Success criteria- Assumptions- Risks-Obstacles- Approval process

Reference

1. Project Management - for 21st Century-Bennet P Lientz, Kathryn Rea, 1995, Academic Press.
2. The Essentials of Project Management-Dennis Lock, 2014, Gower Publishing Ltd.
3. Project management - David I Cleland, 1999, Mcgraw Hill International Edition.
4. Project Management-Harvey, 2009, Maylor-Pearson Publication.

Module 2 **(13 Hours)**

Project Implementation: Project resource requirements- Types of resources: men, materials, finance.

Project Monitoring: Evaluation- Control- Project network technique- Planning for monitoring and evaluation- Project audits- Project management information system- Project scheduling- PERT & CPM- Project communication- Post project reviews

Reference

1. Project Management - for 21st Century-Bennet P Lientz, Kathryn Rea, 1995, Academic Press.
2. The Essentials of Project Management-Dennis Lock, 2014, Gower Publishing Ltd.
3. Project management - David I Cleland, 1999, Mcgraw Hill International Edition.
4. Project Management-Harvey, 2009, Maylor-Pearson Publication.

Module 3 **(15 Hours)**

Project Team Management: Recruitment- Organizing- Human Resources- Team operating rules- Project Organization- Various forms of project organizations- Project organization charting, project contracts, principles- Compilation of contracts- Practical aspects- Legal aspects- Global tender- Negotiations- Insurance.

Reference

1. Project Management - for 21st Century-Bennet P Lientz, Kathryn Rea, 1995, Academic Press.
2. The Essentials of Project Management-Dennis Lock, 2014, Gower Publishing Ltd.
3. Project management - David I Cleland, 1999, Mcgraw Hill International Edition.
4. Project Management-Harvey, 2009, Maylor-Pearson Publication.

Module 4 **(15Hours)**

Closing the Project: Types of project termination- Strategic implications- Project in trouble-- Evaluation of termination possibilities- Termination procedures

Project Inventory Management: Nature of project inventory- Supply and transportation of materials

Reference

1. Project Management - for 21st Century-Bennet P Lientz, Kathryn Rea, 1995, Academic Press.
2. The Essentials of Project Management-Dennis Lock, 2014, Gower Publishing Ltd.
3. Project management - David I Cleland, 1999, Mcgraw Hill International Edition.
4. Project Management-Harvey, 2009, Maylor-Pearson Publication.

CBRES509: ENERGY CONSERVATION TECHNIQUES

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the importance of energy conservation and energy conservation act and its features.

CO2: Know the need, procedures and classification of waste minimization

CO3: Describe about energy conservation methods in electrical systems.

CO4: Describe about energy conservation methods in thermal systems.

CO5: Familiarize with energy conservation in housing and commercial building.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	1	1	-	1	1	1	2	1
CO2	Understand	2	1		1	-	2	2	1	1	1
CO3	Understand	1	1	1	2	-	2	2	1	1	-
CO4	Understand	1	1	1	3	-	1	2	1	1	1
CO5	Understand	1	2	1	3	-	2	2	1	2	1
	Average	**1.20**	**1.20**	**1.00**	**2.00**	-	**1.60**	**1.80**	**1.00**	**1.40**	**1.00**

Module 1 **(18 Hours)**

Introduction

Energy conservation & its importance - The Energy Conservation Act 2001 & its features

Waste Minimization & Resource Conservation

Need of waste minimization - Waste minimization method & its classification - Effects of waste environment & Role of pollution control board - Case study.

Reference

1. Energy Conservation in the Chemical & Allied Industries; S.K. Awasthi, 1989, South Asian Publishers, New Delhi
2. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
3. Industrial Energy Conservation; Melvin H. Chiogioji, 1979, M. Dekker

Module 2 **(18 Hours)**

Energy Conservation Methods in Electrical System

Energy conservation in Motor- Power factor improvement techniques - Effects of harmonics - Star-Delta conversion techniques - Variable speed drive (VSD) - Energy conservation in electric furnaces. - Pumps, Compressors, Fans & Blowers

Reference

1. Energy Conservation in the Chemical & Allied Industries; S.K. Awasthi, 1989, South Asian Publishers, New Delhi
2. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
3. Industrial Energy Conservation; Melvin H. Chiogioji, 1979, M. Dekker

Module 3 **(19 Hours)**

Energy Conservation in Thermal System

Boiler - Steam distribution system -HVAC - Waste heat recovery - Insulation of pipes - Condensate recovery - Fuel Handling - Other heat based application - Case Study.

Reference

1. Energy Conservation in the Chemical & Allied Industries; S.K. Awasthi, 1989, South Asian Publishers, New Delhi
2. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
3. Industrial Energy Conservation; Melvin H. Chiogioji, 1979, M. Dekker

Module 4 **(15 Hours)**

Energy Conservation in Housing & Commercial Building

In Lighting System - Water heating system - Optimization cooking method - Energy efficient building.

Reference

1. Energy Conservation in the Chemical & Allied Industries; S.K. Awasthi, 1989, South Asian Publishers, New Delhi
2. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
3. Industrial Energy Conservation; Melvin H. Chiogioji, 1979, M. Dekker

Additional Reading

1. www.bee-india.com
2. Energy Efficiency in Thermal Utilities, 2010, BEE guide book.
3. Energy Efficiency in Electrical Utilities, 2010, BEE guide book.

CBRES5P06: ADVANCED SOLAR PHOTOVOLTAIC LAB

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Apply the theoretical knowledge to evaluate the performance analysis of IV characteristics of PV module

CO2: Apply the theoretical knowledge to evaluate the temperature dependence and light intensity in PV module parameters like open circuit voltage and short circuit current

CO3: Apply the theoretical knowledge to evaluate the temperature dependence and light intensity in PV module

CO4: Apply the theoretical knowledge to evaluate the PV characteristics of a PV module with variation in intensity of radiation and at different temperatures

CO5: Apply the theoretical knowledge to evaluate the I-V and P-V characteristics with different combination of modules.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	3	1	1	3	-	1	1	2	2	1
CO2	Apply	3	-	1	3	-	1	1	2	2	1
CO3	Apply	3	-	1	3	-	1	1	2	2	1
CO4	Apply	3	-	1	3	-	1	1	2	2	1
CO5	Apply	3	-	1	3	-	1	1	2	2	1
	Average	**3.00**	**1.00**	**1.00**	**3.00**	**-**	**1.00**	**1.00**	**2.00**	**2.00**	**1.00**

1. Series and Parallel connection of solar cells
2. Study the temperature dependence of open-circuit voltage and short-circuit current of a solar cell
3. Study the variation of open-circuit voltage and short-circuit current of a solar cell with light intensity
4. I-V characteristics of a PV Module-Calculation of series and shunt resistance
5. I-V characteristics of a PV module with variation in intensity of radiation.
6. P-V characteristics of a PV module with variation in intensity of radiation.
7. I-V characteristics of a PV module at different temperatures
8. P-V characteristics of a PV module at different temperatures
9. I-V characteristics with series combination of modules.
10. I-V characteristics with parallel combination of modules.
11. P-V characteristics with series combination of modules.
12. P-V characteristics with parallel combination of modules.

Note: Few more Experiments of the same or above standards can be added

CBRES5P07: ADVANCED SOLAR THERMAL LAB - I

Credit: 4 **Total Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Apply the theoretical knowledge to evaluate different paramters related to flat plate collector thermosyphonic mode of flow with different tilt angle

CO2: Apply the theoretical knowledge to evaluate different paramters related to flat plate collector in forced mode of flow with fixed input parameters

CO3: Apply the theoretical knowledge to evaluate different parameters of Flat-Plate Collector in forced mode of flow for different radiation level, input temperature and tilt angle

CO4: Apply the theoretical knowledge to determine the performance of the Parabolic Trough collector with fixed input parameters (Forced mode).

CO5: Apply the theoretical knowledge to determine the performance of the Parabolic Trough collector for different input parameters (Forced mode).

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	-	1	3	-	1	1	1	1	2
CO2	Apply	2	-	1	3	-	1	1	1	1	2
CO3	Apply	2	-	1	3	-	1	1	1	1	2
CO4	Apply	2	-	1	3	-	1	1	1	1	2
CO5	Apply	2	-	1	3	-	1	1	1	1	2
	Average	**2.00**	-	**1.00**	**3.00**	-	**1.00**	**1.00**	**1.00**	**1.00**	**2.00**

1. Evaluation of different parameters of Flat-Plate Collector in thermosyphonic mode of flow with different tilt angle
2. Evaluation of different parameters of Flat-Plate Collector in forced mode of flow with fixed input parameters
3. Evaluation of different parameters of Flat-Plate Collector in forced mode of flow for different flow rate
4. Evaluation of different parameters of Flat-Plate Collector in forced mode of flow for different radiation level
5. Evaluation of different parameters of Flat-Plate Collector in forced mode of flow with different inlet water temperature
6. Evaluation of different parameters of Flat-Plate Collector in forced mode of flow for different tilt angle.

7. To determine the performance of the Parabolic Trough collector with fixed input parameters (Forced mode).
8. To determine the performance of the Parabolic Trough collector for different flow rates (Forced mode).
9. To determine the performance of the Parabolic Trough collector for different radiation level (Forced mode).
10. To determine the performance of the Parabolic Trough collector with different inlet water temperature (Forced mode).
11. To determine the performance of the Parabolic Trough collector for various wind speed (convection losses).
12. To determine the variation of mean water-temperature in the storage tank with different tank volumes.

Note: Few more Experiments of the same or above standards can be added

SEMESTER VI

CBREG612: BIOMASS TECHNOLOGIES AND GEOTHERMAL POWER GENERATION

Credit: 4 **Total: 56 Hours**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Learn how Energy is obtained from Biomass Sources and their Conversion technologies.

CO2: Classify gasifiers and understand their application.

CO3: Explain the basic concepts of biomass technologies and generation of biofuels.

CO4: Understand on anaerobic digestion and biomass combined heat and power

CO5: Understand Geothermal power generation and different Types of geothermal resources.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	1	-	-	1	2	1	2	2
CO2	Understand	2	2	1	-	-	1	2	2	1	1
CO3	Understand	1	2	1	-	-	1	1	1	-	-
CO4	Understand	1	2	1	-	-	1	-	1	1	-
CO5	Understand	1	2	1	-	-	1	2	-	1	1
	Average	**1.40**	**2.00**	**1.00**	-	-	**1.00**	**1.75**	**1.25**	**1.25**	**1.33**

Module 1 **(12 Hours)**

Energy from Biomass-Sources-Conversion Technologies-Biogas Generation-Biogas Plants-Classification-Advantages and Disadvantages-Design

Reference

1. Non-conventional energy sources; G. D. Rai, 2011, Fifth Edition, Khanna Publishers

Module 2 **(14 Hours)**

Methods for Energy From biomass -Thermal gasification- Classification of gasifiers-Application of gasifiers-Problems-Pyrolysis (Destructive distillation)-Alternative liquid fuels (Alcohol Fuels)

Reference

1. Non-conventional energy sources; G. D. Rai, 2011, Fifth Edition, Khanna Publishers

Module 3 **(15 Hours)**

Biomass technologies-Carbon cycle-Biofuels-Ethanol-bio diesel and green fuels-bio fuel from algae-Anaerobic digestion-Bio mass combined heat and power

Reference

1. Renewable energy systems, David M Buchla, Thomas E kissell, Thomas L Flyod

Module 4 **(15 Hours)**

Geothermal power generation- Types of geothermal resources-Geo thermal electrical power-Geo thermal heta pumps-Environmental impacts

Reference

1. Renewable energy systems, David M Buchla, Thomas E kissell, Thomas L Flyod

CBREG613: POWER ELECTRONICS

Credit: 4 **Total: Hours 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Study Field Effect Transistors and their working.

CO2: Explain about thyristors, SCR, DIAC, and TRIAC.

CO3: Familiarize with UJT and SCS

CO4: Familiarize with Power Amplifiers.

CO5: Understand the classification of power amplifiers

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	2	1	1	-	1	1	1	-	-
CO2	Understand	2	1	1	1	-	1	-	1	-	-
CO3	Understand	2	1	1	1	-	1	-	1	-	-
CO4	Understand	2	1	1	1	-	1	-	1	-	-
CO5	Understand	2	1	1	1	-	1	-	1	-	-
	Average	**2.00**	**1.20**	**1.00**	**1.00**	**-**	**1.00**	**1.00**	**1.00**	**-**	**-**

Module 1 **(12 Hours)**

Field-Effect Transistors (FET)

Types of FET- Junction FET (JFET)- Formation of depletion region-Operation-Characteristics-Drain Characteristics-Transfer characteristics-JFET parameters-MOSFETs-Types-Depletion type-Enhancement type-CMOS

Reference

1. A Textbook of Applied Electronics; R.S. Sedha, 2005, S. Chand and Co.

Module 2 **(13 Hours)**

Thyristors, SCR, DIAC, TRIAC

Basic ideas and Types of Thyristors-Silicon Controlled Rectifier (SCR)-operation-equivalent circuit-Characteristics- applications- Basic construction of Diac- V-I characteristic-Applications-TRIAC- Operation- V-I Characteristics-Applications

Reference

1. A Textbook of Applied Electronics; R.S. Sedha,2005, S. Chand and Co.

Module 3 **(15 Hours)**

UJT and SCS

Uni Junction Transistor (UJT)-construction- Operation- V-I Characteristics-Applications-Basic ideas of Silicon Controlled Switch (SCS)- operation-SCS application-Silicon Unilateral Switch (SUS)-Silicon Bilateral Switch (SBS) - Silicon Asymmetrical Switch (SAS).

Reference

1. A Textbook of Applied Electronics; R.S. Sedha, 2005, S. Chand and Co.

Module 4 **(16 Hours)**

Power Amplifiers

Introduction-Difference between voltage amplifier and power amplifier-AC load line-Classification of power amplifiers-Class A, B, C amplifiers-Characteristics-Efficiency-Class B push pull amplifier-advantages-Cross over distortion.

Reference

1. A Textbook of Applied Electronics; R.S. Sedha, 2005, S. Chand and Co.

CBREG614: FUEL CELLS AND HYDROGEN

Credit: 4 **Total Hours: 56**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Get very detailed knowledge on fuel cells

CO2: Describe different types of fuel cells

CO3: Understand various Hydrogen production techniques

CO4: Discuss various hydrogen storage methods and applications

CO5: Compare different Hydrogen transmission systems.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	2	-	-	2	2	2	-	1
CO2	Understand	1	1	-	-	-	2	1	1	-	-
CO3	Understand	2	2	-	-	-	2	1	1	1	1
CO4	Understand	2	2	1	-	-	2	1	1	1	-
CO5	Understand	2	2	1	-	-	2	1	1	1	-
	Average	**1.60**	**1.60**	**1.33**	-	-	**2.00**	**1.20**	**1.20**	**1.00**	**1.00**

Module 1 **(10 Hours)**

Fuel Cells: History – advantages-types-principle-performance-thermodynamics-fuel cell efficiency-applications: portable power, backup power, transportation Applications, stationary power applications

Reference

1. Designing and Building Fuel cells: Colleen Spiegel, McGraw-Hill, 2007, 1st edition.
2. Fuel Cell fundamentals Wiley, Ryan O'Hayre, Suk-Won-Cha, Whitney G, Fritz, 2016, 3rd edition, New Jersey.
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005, Illustrated Edition Elsevier Academic Press, UK.
4. Fuel Cells and Hydrogen Storage, Andrew B, Michael, PM, 2011, Springer,New York.

Module 2 **(15 Hours)**

Fuel Cell Types: Types of fuel cells - Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Solid Oxide Fuel Cell, Molten Carbonate Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Other Fuel Cells.

Reference

1. Designing and Building Fuel cells: Colleen Spiegel, McGraw-Hill, 2007, 1st edition.
2. Fuel Cell fundamentals Wiley, Ryan O'Hayre, Suk-Won-Cha, Whitney G, Fritz, 2016, 3rd edition, New Jersey.

3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005, Illustrated Edition Elsevier Academic Press, UK.
4. Fuel Cells and Hydrogen Storage, Andrew B, Michael, PM, 2011, Springer, New York.

Module 3 **(20 Hours)**

Hydrogen and production techniques: steam reforming, partial oxidation, water electrolysis, gasification, biological production, photo dissociation, direct thermal or catalytic splitting of water. Issues relate to production

Reference

1. Designing and Building Fuel cells: Colleen Spiegel, McGraw-Hill, 2007, 1st edition.
2. Fuel Cell fundamentals Wiley, Ryan O'Hayre, Suk-Won-Cha, Whitney G, Fritz, 2016, 3rd edition, New Jersey.
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005, Illustrated Edition Elsevier Academic Press, UK.
4. Fuel Cells and Hydrogen Storage, Andrew B, Michael, PM, 2011, Springer, New York.

Module 4 **(10 Hours)**

Hydrogen Storage and Applications: Hydrogen storage options - compressed gas -liquid hydrogen - Hydride - chemical Storage - comparisons. Hydrogen transmission systems. Applications of Hydrogen.

Reference

1. Designing and Building Fuel cells: Colleen Spiegel, McGraw-Hill, 2007, 1st edition.
2. Fuel Cell fundamentals Wiley, Ryan O'Hayre, Suk-Won-Cha, Whitney G, Fritz, 2016, 3rd edition, New Jersey.
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005, Illustrated Edition Elsevier Academic Press, UK.
4. Fuel Cells and Hydrogen Storage, Andrew B, Michael, PM, 2011, Springer, New York.

CBRES610: ENERGY MANAGEMENT AND AUDITING

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understand the importance of energy conservation and waste minimization.

CO2: Describe about energy conservation methods in electrical systems.

CO3: Describe about Management of energy conservation methods

CO4: Discuss on energy action plan.

CO5: Familiarize with energy conservation in housing and commercial building.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	3	1	2	-	2	2	1	1	-
CO2	Understand	2	3	1	1	-	2	1	1	1	-
CO3	Understand	2	2	1	-	-	2	1	1	1	-
CO4	Understand	1	1	1	-	-	1	2	1	1	-
CO5	Understand	1	1	1	-	-	1	2	1	1	-
	Average	**1.60**	**2.00**	**1.00**	**1.50**	-	**1.60**	**1.60**	**1.00**	**1.00**	-

Module 1 **(15 Hours)**

Energy Scenario - Introduction - Types of energy sources - Indian energy scenario-Energy V/s economic growth - Energy Policies, pricing & reforms. - Energy security - Energy strategy for future

Basic of energy & its various forms - Various forms of energy - Terms & definitions used in electrical energy - Terms & definitions used in thermal energy -Energy - Units & Conversion

Reference

1. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
2. General Aspects of Energy Management & Energy Audit, Bureau of Energy Efficiency

Module 2 **(20 Hours)**

Energy Management & Audit - Definition and Objective of Energy Management - Principle of Energy Management - Energy Management skills - Energy Management Strategies

Energy Audit - Types & Methodology - Energy Audit Reporting format - understanding energy carts - Bench marking & energy performance - Matching energy usage to requirement - Maximizing System - Fuel & energy Substitution

Reference

1. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
2. General Aspects of Energy Management & Energy Audit, Bureau of Energy Efficiency.

Module 3 **(20Hours)**

Initializing and Organizing - Managing Energy Management Programmers - Organizing Energy Management Programmers -Initializing Energy Management Programmers - Initializing Planning, Leading, Controlling - Promoting, Monitoring and Reporting.

Energy Action Planning - Key Elements - Force Field Analysis - Energy Policy - Organizing - Location of energy Manager - Top Management Support - Energy Manager: Responsibilities & duties to be assigned under energy conservation Act 2001 - accountability-Motivation of Employees - Requirements for Energy Action Planning - Information System-marketing & Communicating - Planning & Training.

Reference

1. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
2. General Aspects of Energy Management & Energy Audit, Bureau of Energy Efficiency

Module 4 **(15 Hours)**

Energy Audit Instruments - Principal and working of Electrical Measuring Instruments (Voltmeter, ammeter ,Power Factor meter, Tri-vector meters for , Speedometer contact /non-contact type) - Flue gas analyzer , Principal of measurements by Chemical Methods, Electronic Methods, - Temperature Measurement Contact type methods, Non Contact type methods - Pressure and velocity Measurement (Bourdon gauge, Manometers, Anemometer) - Flow Measurement of steam, water and air -Humidity Measurement and leak Detectors.

Reference

1. Energy Management Handbook; Wayne C. Turner, 2001, Fairmont Press
2. General Aspects of Energy Management & Energy Audit, Bureau of Energy Efficiency

CBRES6P08: ADVANCED SOLAR THERMAL LAB - II

Credit: 4 **Total: Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Apply the installation procedure to flat plate collector

CO2: Apply the installation procedure to solar water heater

CO3: Apply the theoretical knowledge to study the performance of parabolic collector

CO4: Analyze the procedure to construct a solar cooker and assembling and installing

CO5: Analyze the procedure to assembling and installing a solar drier, solar tracker

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	-	1	3	-	1	1	1	1	2
CO2	Apply	2	-	1	3	-	1	1	1	1	2
CO3	Apply	2	-	1	3	-	1	1	1	1	2
CO4	Apply	2	-	1	3	-	1	1	1	1	2
CO5	Apply	2	-	1	3	-	1	1	1	1	2
Average		**2.00**	-	**1.00**	**3.00**	-	**1.00**	**1.00**	**1.00**	**1.00**	**2.00**

1. Installation of a flat-plate collector
2. To determine the performance of the Parabolic Trough collector with varying solar radiation
3. To determine the effect of tilt on the performance of the Parabolic Trough collector.
4. Installation of solar water heater
5. Performance analysis of a solar water heater under full sun
6. Performance analysis of a solar water heater by varying the radiation intensity
7. Construction of a solar cooker
8. Study the performance of a solar cooker using different types of raw food items
9. Assembling and installing a solar drier
10. Performance analysis of a solar drier
11. Familiarization of a solar tracker
12. Installation of solar tracker

Note: Few more Experiments of the same or above standards can be added

CBRES6P09: EXPERIMENTAL TECHNIQUES AND POWER ELECTRONICS

Credit: 4 **Total: Hours: 112**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Apply the theory of JFET and UJT to study the characteristics of it

CO2: Apply the necessary theory of SCR to study its characteristics and understand the application

CO3: Apply the theory of DIAC and TRIAC to study its characteristics

CO4: Apply the theory to study MOSFET characteristics

CO5: Familiarize thermal evaporation and different gauges and calculate the pumping speed of different types of pumps

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	-	-	1	3	-	1	1	1	1	1
CO2	Apply	-	-	-	3	-	1	1	1	1	1
CO3	Apply	-	-	-	3	-	1	1	1	1	1
CO4	Apply	-	-	-	3	-	1	1	1	1	1
CO5	Apply	-	-	1	3	-	1	1	1	1	2
Average			**-**	**1.00**	**3.00**	**-**	**1.00**	**1.00**	**1.00**	**1.00**	**1.20**

1. JFET characteristics (Static drain Characteristics-Calculation of parameters)
2. UJT characteristics
3. SCR. Characteristics
4. DIAC Characteristics
5. TRIAC Characteristics
6. MOSFET characteristics
7. Familiarization of Pirani and Penning Gauge
8. Pumping speed of rotary pump
9. Pumping speed of diffusion pump
10. Study of degassing
11. Familiarization of thermal evaporation
12. Familiarization of radiant heater and temperature controller

Note: Few more Experiments of the same or above standards can be added

PROJECT

CBRES6PJ: PROJECT

Credit: 4 **Total Hours: 140**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Identify the scientific problem and state the hypothesis

CO2: Identify the various approaches in dealing the scientific problem

CO3: Apply the theoretical knowledge to solve the problem

CO4: Analyse the results and draw valid inferences

CO5: Evaluate the presentation and communication skill

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	2	2	3	1	1	2	-	1
CO2	Analyse	1	2	2	2	3	1	1	1	-	1
CO3	Analyse	2	3	2	2	3	1	1	2	-	2
CO4	Analyse	1	1	1	3	3	1	-	-	1	-
CO5	Analyse	2	1	-	-	3	-	1	2	-	-
	Average	**1.40**	**1.60**	**1.75**	**2.25**	**3.00**	**1.00**	**1.00**	**1.75**	**1.00**	**1.33**

For the completion of degree programme every student shall do a project work under the supervision of a teacher/ an industry expert and submit the project dissertation. The mark distribution is given below.

Components of Project evaluation	Marks
ISA	
Quality of Work	5
Presentation	5
Report	10
ESA	80
Total	**100**

CHOICE BASED SKILL COURSES

CBRES5E01: SOLAR PHOTOVOLTAIC ENERGY CONVERSION - II

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Understanding of various solar cell design constraints

CO2: Knowledge about different solar cell fabrication techniques

CO3: Understand about various thin film fabrication methods

CO4: Understanding about various PV system configurations like standalone, grid connected and hybrid system

CO5: Ability to design a stand-alone system according to our load requirements

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	2	1	-	-	2	1	1	1	1
CO2	Understand	2	2	1	-	-	1	1	1	1	1
CO3	Understand	2	2	1	-	-	1	1	1	1	-
CO4	Understand	2	2	1	-	-	1	-	1	1	-
CO5	Apply	2	2	1	1	-	2	1	1	1	-
	Average	**1.80**	**2.00**	**1.00**	**1.00**	**-**	**1.40**	**1.00**	**1.00**	**1.00**	**1.00**

Module 1 **(15 Hours)**

Design of Solar Cells - Upper limits of cell parameters: Short circuit current-open circuit voltage, fill factor - Losses in Solar cells - Model of a solar cell- effect of series and shunt resistance, solar radiation and temperature on the efficiency of solar Cells-Solar cell design (qualitative)

Reference

1. Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki; 2011, Prentice Hall of India.
2. Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus; 2003, John Wiley and Sons.

Module 2 **(20 Hours)**

c-Si Solar Cells, GaAs Solar Cells, Poly crystalline Si Solar Cells, a-Si Solar Cells

Thin Film Solar Cells: Various layers of Thin film solar cells: Absorber layer, Window layer (CdS), Transparent conducting oxides (FTO, ZnO)

Examples for thin film solar cells: CdTe, CIGS, CZTS based solar cells.

Other Solar Cell technologies: organic solar cells, Dye sensitized Solar cells, Quantum Dot sensitized Solar cells (qualitative)

Reference

1. Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki, 2011, Prentice Hall of India.
2. Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus, 2003, John Wiley and Sons.

Module 3 **(20 Hours)**

Material Fabrication Technologies

Purification of silicon, zone refining and gettering, segregation coefficient.Growth of crystalline silicon, Bridgmann, Czochralski and floating zone methods.

Epitaxial growth methods, MBE, MOCVD, LPE, VPE.

Thin film deposition methods, evaporation, sputtering, wet chemical, spray pyrolysis, screen printing.

Reference

1. Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki, 2011, Prentice Hall of India.
2. Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus, 2003, John Wiley and Sons.

Module 4 **(15 Hours)**

Photovoltaic System Design and applications - Introduction to Solar PV systems, Standalone PV system configuration: Type a, Type b, Type c, Type d, Type e, Type f- Hybrid PV systems : types of hybrid systems, issues -Simple Payback period - Life Cycle Costing: Time Value of money, Present worth of future one time investment, Present worth of future recurring investments, Life cycle cost-Annualised Life cycle costing-Unit cost of generated electricity.

Reference

1. Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki, 2011, Prentice Hall of India.
2. Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus, 2003, John Wiley and Sons.

Additional reading

1. Physics of Solar Cells by Jenny Nelson.
2. Solar Cells by Martin Green.

CBRES5E02: SOLAR THERMAL TECHNOLOGY - II

Credit: 5 **Total Hours: 70**

Course Outcomes

Upon completion of the course, the student will be able to:

CO1: Commission, do maintenance and servicing of solar thermal system

CO2: Understand about solar air system, solar cooling

CO3: Discuss about large scale solar systems

CO4: Understand solar concentrating systems

CO5: Have basic knowledge about simulation programme for solar thermal system

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	1	1	-	-	2	1	1	1	1
CO2	Understand	1	1	1	1	-	2	1	1	1	1
CO3	Understand	1	1	1	1	-	2	1	1	1	1
CO4	Understand	1	1	1	-	-	2	1	-	-	-
CO5	Understand	1	1	1	-	-	1	1	-	-	-
Average		**1.20**	**1.00**	**1.00**	**1.00**	**-**	**1.80**	**1.00**	**1.00**	**1.00**	**1.00**

Module 1 **(15 Hours)**

Components of Solar Thermal Systems: How Does a Solar Thermal System Work- Collectors- Heat Stores- Solar Circuit-Controller

Systems for Single-Family Houses: Systems for Charging/Discharging the Store - Systems for Heating Domestic Water-Systems for Heating Domestic Water and Space Heating- Planning and Dimensioning-Costs and Yields

Installation, Commissioning, Maintenance and Servicing: A Brief Study of Roofing and Materials- Installation Methods and Safety- Installation-Starting Up, Maintenance and Servicing- Information Sources for Specific Countries

Textbook

1. Planning and Installing Solar Thermal Systems: A Guide for Installers, Architects and Engineers by German Solar Energy Society (DGS); 2010, Earthscan

Module 2 **(20 Hours)**

Large-scale Systems

Systems- Control of the Systems- Heat Exchangers- Safety Technology- Economic Considerations- Solar Contracting- Solar District Heating

Solar Concentrating Systems

Concentration of Solar Radiation- Concentrating Systems Providing Process Heat- Concentrating Solar Thermal Systems for Electricity Generation

Textbook

1. Planning and Installing Solar Thermal Systems: A Guide for Installers, Architects and Engineers by German Solar Energy Society (DGS); 2010, Earthscan.

Module 3 **(20 Hours)**

Solar Air Systems: Introduction- Components- Systems- Planning and Dimensioning- Installation- Costs and Yields- Examples

Solar Cooling: Theoretical Bases- Integrated Planning of Solar Cooling/Air-conditioning Systems- System Technology- System Design

Text book

1. Planning and Installing Solar Thermal Systems: A Guide for Installers, Architects and Engineers by German Solar Energy Society (DGS); 2010, Earthscan.

Module 4: **(15 Hours)**

Simulation Programs for Solar Thermal Systems

Introduction- Evaluation of Simulation Results- Simulation with Shading- Market Survey, Classification and Selection of Simulation Programs- Brief Description of Simulation Programs.

Textbook

1. Planning and Installing Solar Thermal Systems: A Guide for Installers, Architects and Engineers by German Solar Energy Society (DGS); 2010, Earthscan

GENERAL COURSES IN ENGLISH FOR BVoc PROGRAMME

SEMESTER I

CCENG101: BASIC ENGLISH WRITING

Credit: 4 **Total Hours: 56**

Course Outcomes

On successful completion of the course, students shall be able to:

CO1: Write short paragraphs observing the structural format.

CO2: Write letters and E-mails effectively.

CO3: Produce coherent essays of different types using appropriate cohesive devices.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	-	-	-	-	2	-	2	1	1
CO2	Apply	2	-	-	-	-	2	-	2	1	1
CO3	Apply	2	-	-	-	-	2	-	2	1	1
	Average	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**2**	**1**	**1**

Module 1: Paragraph Writing **(18 Hours)**

1. Writing Process: Pre-Writing, Structure and Revision
2. Practising Paragraph Writing

Module 2: Informal and Formal Communication **(19 Hours)**

1. Informal Letters
2. Formal Letters
3. Business Letters
4. Writing E-mails

Module 3: Essay Writing **(19 Hours)**

1. Descriptive Essays
2. Narrative Essays
3. Cause-and-Effect Essays
4. Argumentative Essays

Course designed by: Dr Benny Mathew

SEMESTER II

CCENG202: ESSENTIAL SPOKEN SKILLS AND GRAMMAR

Credit: 4 **Total Hours: 56**

Course Outcomes

On successful completion of the course, students shall be able to:

CO1: Draft an effective job application and CV

CO2: Attend an interview with confidence and with clarity of purpose.

CO3: Articulate oneself in Group Discussions observing the etiquettes in language and manners

CO4: Apply their knowledge of English grammar in appropriate contexts

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Apply	2	-	-	-	-	2	-	2	2	2
CO2	Apply	2	-	-	-	-	2	-	2	2	2
CO3	Apply	2	-	-	-	-	2	-	2	2	2
CO4	Apply	2	-	-	-	-	2	1	1	1	1
	Average	**2**	**-**	**-**	**-**	**-**	**2**	**1**	**1.75**	**1.75**	**1.75**

Module 1: Job Applications and CV **(18 Hours)**

1. Writing cover letter and application letter
2. Writing CV, Resume, Biodata

Module 2: Interview and Group Discussion **(20 Hours)**

1. Interview language skills
2. Preparing for interview
3. Practising Interview
4. Group Discussion: importance, GD etiquette, GD language
5. Doing GD

Module 3: English for Competitive Exams: Remedial Grammar **(18 Hours)**

1. Articles
2. Tenses: Past, Present and Future - Major uses
3. Subject-Verb agreement
4. Preposition
5. Reported Speech
6. Passive

Course designed by: Dr Raju Sebastian

GENERAL COURSES IN MATHEMATICS FOR BVoc PROGRAMME

SEMESTER I

CDMMG101: MATHEMATICS - I

Credit: 4 **Total: 56 Hours**

Course Outcomes

CO1: Develop basic knowledge about sets and functions

CO2: Analyze the properties of complex numbers and the geometric representation of their sum and differences

CO3: Evaluate the limits of different functions and observe their continuity

CO4: Computing the derivatives of various functions using standard results and chain rule.

CO5: Construct diagrams and graphs and examine data using statistical tools.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	1	1	1	1	-	1	1	1	1	-
CO2	Apply	1	-	-	-	-	1	-	-	-	-
CO3	Apply	2	-	2	1	-	1	-	2	1	-
CO4	Apply	2	-	2	1	-	1	-	2	1	-
CO5	Apply	1	1	2	1	-	1	1	2	1	-
	Average	**1.4**	**1**	**1.75**	**1**	**-**	**1**	**1**	**1.75**	**1**	**-**

Module 1: Basic Set Theory **(14 Hours)**

Sets and Functions Power set of a set, Product of two sets, Equivalence relations, partitions of sets, Equivalence classes Definition of a function. Domain, co- domain and the range of a function, Review of injective, surjective and bijective functions, Composition of functions. Invertible functions and the inverse of a function, Graphing of functions

Reference

1. Lipschutz, *Set Theory and Related Topics*, , 2nd Edition, Schaum Outline Series, Tata McGraw Hill Publishing Company, New Delhi, 2009
2. K. H. Rosen, *Discrete Mathematics and its Applications*, 6th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2008

Module 2: Complex Numbers **(14 Hours)**

Complex Numbers Complex numbers, Addition and multiplication of complex numbers, Modulus, Real and imaginary parts, conjugate and amplitude of a complex number, Polar form of complex number, Geometric representation of the sum and difference

Reference

1. E. B. Staff and A. D. Snider, *Fundamentals of Complex Analysis*, 3rd Edition, Pearson Education, 2009

Module 3: Differentiation **(12 Hours)**

Limit, Continuity and Differentiability Limits of Functions, calculating limits using the limit laws, one sided limits and limits at infinity, Continuity, Rates of change and Differentiability, standard results, Differentiation Rules, Chain Rule.

Reference

1. George B. Thomas Jr, *Thomas' Calculus*, 11th Edition, Pearson, 2008

Module 4: Basic Statistics **(16 Hours)**

Statistical Methods of Analysis Types of data: - quantitative, qualitative. Classification and Tabulation. Diagrammatic representation: - Bar diagram, pie diagram; pictogram and cartogram. Graphical 9 representations: - histogram; frequency polygon; frequency curve; ogives. Measures of Central Tendency: - Mean; Median; Mode; Geometric Mean; Harmonic Mean and Properties. Absolute and Relative measures of Dispersion: - Range, Quartile Deviation, Mean Deviation, Standard Deviation, Coefficient of Variation

Reference

1. S.P. Gupta, *Statistical Methods,* Sultan Chand & Sons Delhi, 2021
2. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, 2018

Course Designed by: Jinu Mary Jameson

SEMESTER II

CDMMG202: MATHEMATICS - II

Credit: 4 **Total Hours: 56**

Course Outcomes

CO1: Calculate extreme values using techniques of differential calculus

CO2: Apply Partial derivatives to several variable functions.

CO3: Develop Basic knowledge about Matrices and their properties.

CO4: Compute various matrix operations and perform various elementary transformations of a matrix.

CO5: Illustrate various methods of Numerical Analysis.

Course Mapping Table

	Cognitive Level	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CO1	Understand	2	-	1	1	-	1	2	2	1	-
CO2	Apply	2	-	1	1	-	1	2	2	1	-
CO3	Apply	1	-	1	-	-	1	1	1	1	-
CO4	Apply	1	-	1	-	-	1	1	1	1	-
CO5	Apply	2	-	2	1	-	1	1	2	1	-
	Average	**1.6**	**-**	**1.2**	**1**	**-**	**1**	**1.4**	**1.6**	**1**	**-**

Module 1: Applications of Derivatives **(14 Hours)**

Applications of Derivatives, Extreme values of functions, The Mean Value Theorem, Monotonic functions and the first derivative test. (Proofs Excluded)

Reference

1. George B. Thomas Jr, *Thomas' Calculus*, 11th Edition, Pearson, 2008

Module 2: Partial Derivatives **(14 Hours)**

Partial Derivatives: Functions of several variables (Definition only), Partial derivatives, The Chain Rule.

Reference

1. George B. Thomas Jr, *Thomas' Calculus*, 11th Edition, Pearson, 2008.

Module 3: Matrices **(14 Hours)**

Theory of Matrices: Definition, Types of Matrices, Operations on Matrices, Transpose of a Matrix, Elementary Tranformations of a Matrix, Invertible Matrices, Finding Rank and Inverse of a Matrix using elementary row transformations.

Reference

1. Frank Ayres Jr , *Matrices*, TMH Edition , Schaum's Outline Series, 1974
2. Shanthi Narayanan and P. K. Mittal, *A Text Book of Matrices,* S. Chand, 2010

3. David W. Lewis, *Matrix Theory*, Allied Publications, 1991

Module 4: Numerical Methods **(14 Hours)**

Numerical Analysis, Bisection Method, Method of False Position, Iteration Method, Newton-Raphson Method.

Reference

1. S. S. Sastry, *Introductory Methods of Numerical Analysis*, 4th Edition, PHI, 2005

Course designed by: Tibin Thomas

Programme Articulation Table

Course Code	Course Title	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CCENG101	Basic English Writing	2	-	1	-	-	-	-	2	1	1
CDMMG101	Mathematics – I	1.4	1	1.75	1	-	1	1	1.75	1	-
CBREG101	Units, Measurements and Basics of Renewable Energy	1.60	1.50	1.00	2.50	1.00	1.20	1.00	1.00	2.50	2.50
CBRES101	Solar PV Installation: Civil and Mechanical	1.75	1.33	1.33	1.67	1.00	1.20	1.00	2.00	1.50	1.75
CBRES102	Solar PV Installation: Operation and Maintenance	2.00	1.00	2.00	1.25	-	2.25	1.00	2.80	1.66	1.00
CBRES1P01	Practical Solar PV Installation, Operation and Maintenance (P)	2.00	1.00	3.00	1.75	1.00	1.25	1.00	2.00	1.60	1.00
CCENG202	Essential Spoken Skills and Grammar	2	-	-	-	-	2	1	1.75	1.75	1.75
CDMMG202	Mathematics – II	1.6	-	1.2	1	-	1	1.4	1.6	1	-
CBREG202	Semiconductor Physics	1.00	-	1.50	1.00	-	-	1.00	-	1.00	1.00
CBRES203	Rooftop Solar Grid Engineering	1.66	1.50	1.00	1.00	-	1.00	1.00	1.00	-	1.00
CBRES204	Energy Storage Systems	1.20	1.20	1.00	1.00	-	1.00	1.00	-	1.20	-
CBRES2P02	Grid Tied Solar Photovoltaic System and Basic Electronics Practical (P)	2.00	2.00	2.00	2.00	-	1.00	1.00	1.00	1.25	1.33
CBRES2HT	HOT	1.00	1.33	1.75	1.25	3.00	1.00	1.00	1.80	1.50	2.00
CBREG303	Fundamentals of Computers	-	-	1.00	-	1.00	1.25	1.00	1.66	1.00	-
CBREG304	Thermodynamics and Fluid Mechanics	1.00	-	1.20	1.00	-	1.00	-	2.00	-	-
CBREG305	Novel Energy Resources	2.40	1.00	2.00	2.00	-	1.00	-	-	1.00	-
CBRES305	Solar Thermal Technology - I	1.80	1.50	2.67	1.50	-	1.20	-	1.00	1.50	1.00
CBRES306	Wind Energy	3.00	1.33	1.00	1.00	-	1.50	2.00	1.00	1.00	-
CBRES3P03	Thermodynamics and Solar Thermal (P)	1.75	-	1.20	1.00	-	2.00	-	-	1.00	-
CBRES3P04	Fluid Dynamics and Wind Energy (P)	1.00	-	1.00	1.00	1.00	2.00	-	-	1.00	-
CBREG406	Analysis of a Solar Thermal system	1.80	1.80	1.25	1.60	1.00	1.50	1.00	1.00	1.00	1.00
CBREG407	Materials for Green Energy	1.80	1.40	1.80	1.40	1.00	2.00	1.60	1.25	1.60	1.80
CBREG408	Environmental Education	1.80	1.20	1.20	1.00	1.00	2.40	2.60	1.00	1.40	1.60
CBRES407	Solar Photovoltaic Energy Conversion – I	2.80	2.80	2.60	2.00	1.00	3.00	2.00	2.00	2.00	1.40

Course Code	Course Title	PSO1	PSO2	PSO3	PSO4	PSO5	PO1	PO2	PO3	PO4	PO5
CBRES408	Entrepreneurship in Solar PV	1.60	1.40	1.80	1.50	1.00	1.80	1.80	1.40	1.60	1.40
CBRES4P05	Solar Photovoltaic (P)	1.80	1.00	1.00	3.00	-	1.00	1.00	1.00	1.00	2.00
CBRES4OJT	OJT	1.40	1.33	3.00	2.00	3.00	1.00	1.75	1.75	1.33	2.00
CBREG509	Lasers and Optical Instrumentation	1.00	1.00	2.00	-	-	3.00	2.80	1.40	2.20	1.25
CBREG510	Environment, Health and Safety in Industries	1.00	1.00	3.00	1.00	-	2.00	1.80	1.00	1.00	1.00
CBREG511	Project Management	1.00	3.00	1.00	1.00	-	1.60	1.00	1.33	1.25	1.00
CBRES509	Energy Conservation Techniques	1.20	1.20	1.00	2.00	-	1.60	1.80	1.00	1.40	1.00
CBRES5P06	Advanced Solar Photovoltaic Lab (P)	3.00	1.00	1.00	3.00	-	1.00	1.00	2.00	2.00	1.00
CBRES5P07	Advanced Solar Thermal Lab – I (P)	2.00	-	1.00	3.00	-	1.00	1.00	1.00	1.00	2.00
CBREG612	Biomass Technologies and Geothermal Power Generation	1.40	2.00	1.00	-	-	1.00	1.75	1.25	1.25	1.33
CBREG613	Power Electronics	2.00	1.20	1.00	1.00	-	1.00	1.00	1.00	-	-
CBREG614	Fuel Cells and Hydrogen	1.60	1.60	1.33	-	-	2.00	1.20	1.20	1.00	1.00
CBRES610	Energy Management and Auditing	1.60	2.00	1.00	1.50	-	1.60	1.60	1.00	1.00	-
CBRES6P08	Advanced Solar Thermal Lab – II (P)	2.00	-	1.00	3.00	-	1.00	1.00	1.00	1.00	2.00
CBRES6P09	Experimental Techniques and Power Electronics (P)	-	-	1.00	3.00	-	1.00	1.00	1.00	1.00	1.20
CBRES6PJ	Project	1.40	1.60	1.75	2.25	3.00	1.00	1.00	1.75	1.00	1.33
Choice Based Skill Courses											
CBRES5E01	Solar Photovoltaic Energy Conversion – II	1.80	2.00	1.00	1.00	-	1.40	1.00	1.00	1.00	1.00
CBRES5E02	Solar Thermal Technology – II	1.20	1.00	1.00	1.00	-	1.80	1.00	1.00	1.00	1.00

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