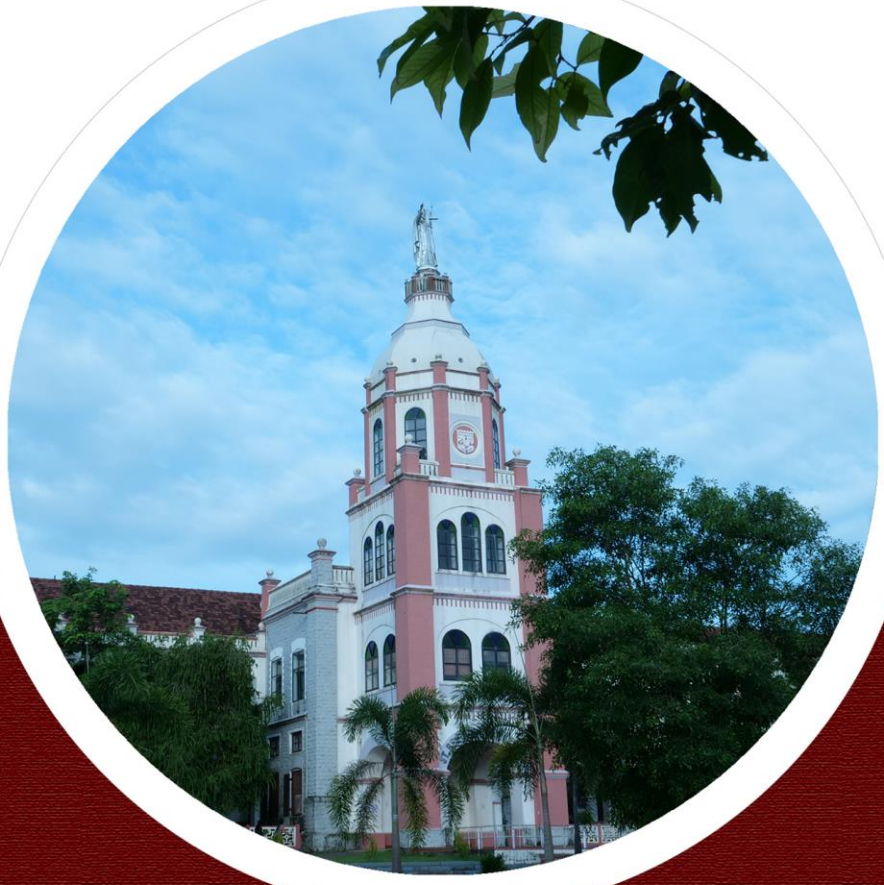
DEPARTMENT OF
PHYSICS



Curriculum and Syllabus for BVoc Programme in Renewable Energy Management Under Credit Semester System

(with effect from 2019 admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

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The University Grants Commission (UGC) has launched a scheme on skills development based higher education as part of college/university education, leading to Bachelor of Vocation (BVoc) Degree with multiple exits such as Diploma/Advanced Diploma under the National Skill Qualification Framework (NSQF).

PROGRAMME OBJECTIVES

The BVoc courses are designed with the following objectives,

a) To provide judicious mix of skills relating to a profession and appropriate content of General Education.

b) To ensure that the students have adequate knowledge and skills, so that they are work ready at each exit point of the programme.

c) To provide flexibility to the students by means of predefined entry and multiple exit points.

d) To integrate NSQF within the undergraduate level of higher education in order to enhance employability of the graduates and meet industry requirements. Such graduates apart from meeting the needs of local and national industry are also expected to be equipped to become part of the global workforce.

REGULATIONS FOR BVOC PROGRAMME IN RENEWABLE ENERGY MANAGEMENT UNDER CREDIT SEMESTER SYSTEM (SB-CSS-BVoc) 2019

1. SHORT TITLE

1.1 These Regulations shall be called St. Berchmans college (Autonomous) Regulations (2019) governing BVoc Programmes under the Credit Semester System (SB-CSS-BVoc)

1.2 These Regulations shall come into force from the Academic Year 2019-2020 onwards

2. SCOPE

2.1 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 2019 - 2020.

3. DEFINITIONS

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

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

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' means a three year programme of study and examinations.

3.7 '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

3.8 '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.

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

3.10 'Complementary Course' means a course which would enrich the study of core courses.

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

3.12 '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.

3.13 '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.

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

3.15 '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.

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

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

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

3.19 'Improvement Course' is a course registered by a student for improving the performance in that particular course.

3.20 'Supplementary Course' is a course that is repeated by a student for having failed in that course in an earlier registration.

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 Grade Point Average' (SGPA) 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 Grade Point Average' (CGPA) 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 First, Second, Third, Fourth and Fifth position shall be awarded to students who come in the first five places on the basis of overall marks in the programme in the first chance itself.

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.

4.2 The credit distribution for the programmes is shown below.

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

4.3 **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.

4.4 **Evaluations**

The evaluation of each course shall contain two parts.

i Internal or n-Semester Assessment (ISA)

ii External or 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.

4.5 **In-semester assessment of theory courses**

There are three components for ISA, which include attendance, assignment/seminar/viva-voce and in-semester examination. All the three components of the internal assessment are mandatory. For Common Course- English, internal oral examination shall be conducted instead of test paper.

Components of ISA	Marks
Attendance	5
Assignment/Seminar/Viva	5
In-semester examination (2×5 = 10)	10
Total	**20**

Marks for attendance

% of Attendance	Marks
90 and above	5
85 - 89	4
80 - 84	3
76 - 79	2
75	1

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

Assignment

Assignments are to be done from 1st to 4th Semesters. At least one assignment should be done in each semester.

Seminar, Viva

A student shall present a seminar in the 5th semester and appear for Viva-voce in the 6th semester.

In-semester examination

Every student shall undergo at least two in-semester examinations as class test as an internal component for theory courses.

4.6 **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**

4.7 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.

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

4.9 **End-semester assessment**

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

4.10 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.

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

4.12 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	Question Type	Number of Questions to be answered	Marks	Total marks
A	Very short answer type	9 out of 12	2	18
B	Short answer	6 out of 8	4	24
C	Short essay	3 out of 5	6	18
D	Long essay	2 out of 4	10	20
Total		**20 out of 29**		**80**

4.13 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.

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

4.15 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.

4.16 **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 (External)	50
Viva-Voce (External)	30
Total	**100**

4.17 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.

4.18 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 Grade Point Average

Semester Grade Point Average (SGPA) is calculated using the formula

SGPA = 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

GPA shall be rounded off to two decimal places.

5.2 Cumulative Grade Point Average

Cumulative Grade Point Average (CGPA) is calculated using the formula

CGPA = 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

GPA shall be rounded off to two decimal places.

5.4 Grade Point Average (GPA) 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

GPA = 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 Grade Point Average (SGPA) and grades for overall programme, Cumulative Grade Point Average (CGPA) are given based on the corresponding Grade Point Average (GPA) as shown below:

GPA	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
3.5 to below 4.5	D	Pass
Below 3.5	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 The eligibility criteria for admission shall be as announced by the College/University from time to time.

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. Semester and Name of the Examination
vii. Month and Year of Examination
viii. Stream
ix. Course Code, Title and Credits of each course opted in the semester
x. 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
xi. Total Credits, Marks Awarded, Credit Point, SCPA and Letter Grade in the semester
xii. 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 'E' 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 STRUCTURE

Semester I

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BCENG101	English - I	3	56	4	20	80	100
BDMMG101	Mathematics - I	3	56	4	20	80	100
BBREG101	Units, Measurements and Basics of Renewable Energy	3	56	4	20	80	100
BBRES101	Solar PV installation: Civil and Mechanical	4	70	5	20	80	100
BBRES102	Solar PV installation: Operation and Maintenance	4	70	5	20	80	100
BBRES1P01	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	Credits	ISA	ESA	Total
BCENG202	English - II	3	56	4	20	80	100
BDMMG202	Mathematics - II	3	56	4	20	80	100
BBREG202	Basic Electronics	3	56	4	20	80	100
BBRES202	Rooftop Solar Grid Engineering	4	70	5	20	80	100
BBRES203	Energy Storage Systems	4	70	5	20	80	100
BBRES2P02	Grid Tied Solar Photovoltaic System (P)	6	112	4	20	80	100
BBRES2HOT	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	Credits	ISA	ESA	Total
BBREG303	Fundamentals of Computers	3	56	4	20	80	100
BBREG304	Thermodynamics and Fluid Mechanics	3	56	4	20	80	100
BBREG305	Novel Energy Resources	3	56	4	20	80	100
BBRES304	Solar Thermal Technology - I	4	70	5	20	80	100
BBRES305	Wind Energy	4	70	5	20	80	100
BBRES3P03	Thermodynamics and Solar Thermal (P)	6	112	4	20	80	100
BBRES3P04	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	Credits	ISA	ESA	Total
BBREG406	Solar Thermal Technology - II	3	56	4	20	80	100
BBREG407	Material Science	3	56	4	20	80	100
BBREG408	Environmental Education	3	56	4	20	80	100
BBRES406	Solar Photovoltaic Energy Conversion - I	4	70	5	20	80	100
BBRES407	Entrepreneurship in Solar PV	4	70	5	20	80	100
BBRES4P04	Solar Photovoltaics (P)	6	112	4	20	80	100
BBRES4OJT	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	Credits	ISA	ESA	Total
BBREG509	Lasers and Optical Instrumentation	3	56	4	20	80	100
BBREG510	Environment, Health and Safety in Industries	3	56	4	20	80	100
BBREG511	Project Management	3	56	4	20	80	100
BBRES508	Energy Conservation Techniques	4	70	5	20	80	100
	Elective Course	4	70	5	20	80	100
BBRES5P05	Advanced Solar Photovoltaic Lab (P)	6	112	4	20	80	100
BBRES5P06	Advanced Solar Thermal Lab - I (P)	6	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	Credits	ISA	ESA	Total
BBREG612	Spectroscopy - Experimental Techniques	3	56	4	20	80	100
BBREG613	Power Electronics	3	56	4	20	80	100
BBREG614	Fuel Cells and Hydrogen	3	56	4	20	80	100
BBRES609	Energy Management and Auditing	4	70	5	20	80	100
BBRES6P07	Advanced Solar Thermal Lab - II (P)	6	112	4	20	80	100
BBRES6P08	Experimental Techniques and Power Electronics (P)	6	112	4	20	80	100
BBRES6PJ	Project		140	5	20	80	100
	Total	**-**	**-**	**30**	**140**	**560**	**700**
	Grand Total	**-**	**-**	**180**	**-**	**-**	**4100**

ELECTIVE COURSES

BBRES5E01	Solar Photovoltaic Energy Conversion - II
BBRES5E01	Solar Thermal Technology - III

SEMESTER I

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BCENG101	English - I	3	56	4	20	80	100
BDMMG101	Mathematics - I	3	56	4	20	80	100
BBREG101	Units, Measurements and Basics of Renewable Energy	3	56	4	20	80	100
BBRES101	Solar PV installation: Civil and Mechanical	4	70	5	20	80	100
BBRES102	Solar PV installation: Operation and Maintenance	4	70	5	20	80	100
BBRES1P01	Practical: Solar PV Installation, Operation and Maintenance (P)	12	224	8	20	80	100
	Total			**30**	**120**	**480**	**600**

BCENG101: ENGLISH - I

Total: 56 hrs

Credits: 4

Business, Social Skills and the Recruitment Process

Each module is comprised of reading section, writing section, grammar and vocabulary. In addition to that each module is supplemented with activities which enable the student to practise what he/she has learnt.

Module 1: Greetings and introduction (10 hrs)

Modes of greetings-samples of greetings-small talk-listening and speaking-

Reading comprehension

Related vocabulary

Grammar –contractions and negatives.

Activities

Module 2: Company profiles /jobs and responsibilities (18 hrs)

Business organisations-famous entrepreneurs –jobs and responsibilities-

Job profiles-job descriptions

Reading comprehension

Vocabulary related to business organisations, jobs and responsibilities.

Grammar: Wh---------- Questions, verbs describing jobs and responsibilities.

Activities.

Module 3: Getting ready for job market and organising a portfolio. (18 hrs)

Organising a portfolio- self –profile making-web version of portfolio-presentation skill

Reading comprehension

Vocabulary for writing profiles

Grammar: present progressive tense.

Activities

Module 4: Responding to Advertisements (10 hrs)

Writing a C.V and letter of application-making the sub heads in a C.V-accepting and declining an

Offer-responding to advertisements-

Reading comprehension

Vocabulary related to CV, application, advertisements, letter writing

Grammar: simple past tense

Activities

Reference Text

Business Communication, BCS-055, IGNOU, Aug, 2013, ISBN: 978-81-266-6504-4

BDMMG101: MATHEMATICS - I

Total: 56 hrs

Credit: 4

Module 1 (15 hrs)

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.

References:

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

Module 2 (15 hrs)

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.

References:

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

Module 3 (10 hrs)

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.

References:

Thomas' Calculus, George B. Thomas Jr., 2008, 11th Edition, Pearson. (Sections 2.1 to 2.6 and 3.1 to 3.2)

Module 4 (16 hrs)

Statistical Methods of Analysis

Types of data:- quantitative, qualitative. Classification and Tabulation. Diagrammatic representation:- Bar diagram, pie diagram; pictogram and cartogram. Graphical

representation:- 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.

References:

1. S.P. Gupta: Statistical Methods (Sultan Chand & Sons Delhi).
2. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
3. B.L. Agarwal: Basic Statistics, New Age International (p) Ltd.
4. Parimal Mukhopadhya: Mathematical Statistics, New Central Book Agency (p) Ltd, Calcutta
5. Murthy M.N.: Sampling theory and Methods, Statistical Publishing Society, Calcutta.

BBREG101: UNITS, MEASUREMENTS AND BASICS OF RENEWABLE ENERGY

Total: 56 hrs

Credit: 4

Module 1 **(13 hrs)**

Measurements: Units Necessity of measurement, concept of unit of a physical quantity, requirements of standard unit, Various system of units (CGS, MKS, SI, FPS), conversions, practical units, fundamental and derived physical quantities and their units, dimensions and dimensional analysis

Reference

Elements of Properties of matter: D. S. Mathur, 2000, 11thEdition,S. Chand and Co.

Module 2 **(15 hrs)**

Measuring instruments: Measurement of time - water clocks - sun dials - pendulum clocks - digital clocks - atomic clocks-Length measurements - rulers - standard meter - micro meters - screw gauges - travelling microscopes - laser range finder - sonar - GPS- Angle Measurements - Spectrometer verniers - scale and telescope - measurement of stellar parallaxes-Electrical measurements - Working principle of galvanometer - voltmeter - ammeter and digital multimeters

Reference

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

Module 3 **(10 hrs)**

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

Reference

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

Module 4 **(18 hrs)**

Solar Energy

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.

References

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.

BBRES101: SOLAR PV INSTALLATION: CIVIL AND MECHANICAL

Total: 70 hrs

Credit: 5

Module 1 **(17 hrs)**

Training code of conduct, job role and career opportunities-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:

Solar PV Installer (Suryamitra) Participant Hand book

Module 2 **(20 hrs)**

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 Hand book
2. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, PHI Learning Pvt, 2013

Module 3 **(22 hrs)**

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.

Textbook:

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

Module 4 **(11 hrs)**

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

Textbook:

Solar PV Installer (Suryamitra) Participant Hand book

References:

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

BBRES102: SOLAR PV INSTALLATION: OPERATION AND MAINTENANCE

Total: 70 hrs

Credit: 5

Module 1 **(20 hrs)**

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

Solar PV Installer (Suryamitra) Participant Hand book

Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, PHI Learning Pvt, 2013

Module 2 **(18 hrs)**

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

Solar PV Installer (Suryamitra) Participant Hand book

Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, PHI Learning Pvt, 2013

Module 3 **(17 hrs)**

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

Solar PV Installer (Suryamitra) Participant Hand book

Module 4 **(15 hrs)**

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

PRACTICAL

BBRES1P01: SOLAR PV INSTALLATION, OPERATION AND MAINTENANCE

Total: 224 hrs

Credit: 8

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

Practical: Physics

1. Verification of Ohm's law

2. Travelling microscope

3. Spectrometer-Angle of prism

4. Series LCR circuit-frequency response

SEMESTER II

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BCENG202	English - II	3	56	4	20	80	100
BDMMG202	Mathematics - II	3	56	4	20	80	100
BBREG202	Basic Electronics	3	56	4	20	80	100
BBRES202	Rooftop Solar Grid Engineering	4	70	5	20	80	100
BBRES203	Energy Storage Systems	4	70	5	20	80	100
BBRES2P02	Grid Tied Solar Photovoltaic System (P)	6	112	4	20	80	100
BBRES2HOT	HOT	6	112	4	20	80	100
	Total			**30**	**140**	**560**	**700**

BCENG202: ENGLISH - II

Total: 56 hrs

Credit: 4

Finishing Skills for Interviews and Placement

Module 1 Preparing for interviews (10 hrs)

Listening comprehension

Reading comprehension

Vocabulary and structure of CV

Grammar: Modals indicating obligation, prefixes

Activities

Module 2 Facing interviews (10 hrs)

Reading comprehension

Listening comprehension

STAR Structure

Body language

Vocabulary

Grammar: Passive

Activities

Module 3 Phone and Walk in Interviews (12 hrs)

Types of interviews

Preparation for interviews

Listening comprehension

Reading comprehension

Vocabulary related to interviews

Grammar: Articles (A/AN/THE)

Activities

Module 4 Group Discussion (12 hrs)

Group discussion types-formalities in GD-

Listening comprehension

Reading comprehension

Do’s and don’ts in a GD

Vocabulary related to GD

Grammar: Non-finite verbs (the participle)

Activities

Module 5 Practice and Training (12 hrs)

Mock interview, C V making, GD, and computer skills in M S Word

Reference Text: Interviews, IGNOU, Aug, 2013, ISBN: 978-81-266-6531-0

BDMMG202: MATHEMATICS - II

Total: 56 hrs

Credit: 4

Module 1 (12 hrs)

Applications of Derivatives:

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

Reference

Thomas' Calculus, George B. Thomas Jr., 2008, 11th Edition, Pearson. (Sections 4.1 to 4.3)

Module 2 (13 hrs)

Partial Derivatives:

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

Reference

Thomas' Calculus, George B. Thomas Jr., 2008, 11th Edition, Pearson. (Sections 14.3 to 14.4)

Module 3 (15 hrs)

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.

References:

1. Matrices: Schaum's Outline Series, Frank Ayres Jr., TMH Edition.
2. A Text Book of Matrices, Shanthi Narayanan and P. K. Mittal, S. Chand Publications.
3. Matrix Theory, David W. Lewis, Allied Publications.

Module 4 (15 hrs)

Numerical Analysis:

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

References:

Introductory Methods of Numerical Analysis, S. S. Sastry, 4th Edition, PHI (Sections 2.2 to 2.5)

BBREG202: BASIC ELECTRONICS

Total: 56 hrs

Credit: 4

Module 1 (12 hrs)

Electronics- Atomic structure-structure of elements-The electron-Energy of an electron-valance electrons-free electrons- Voltage source-Constant voltage source-constant current source.

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

Reference

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

Module 2 (16 hrs)

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

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

Module 3 (16 hrs)

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

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

Module 4 (12 hrs)

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. Therja: S. Chand Co.
2. Elements of electronics- M.K. Bagde, S.P. Singh 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
7. Physics of Semiconductor devices, Dilip K Roy, University Press.
8. Physics of Semiconductor devices, S M Sze, Wiley Eastern Limited

BBRES202: ROOFTOP SOLAR GRID ENGINEERING

Total: 70 hrs

Credit: 5

Module 1 **(20 hrs)**

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 hrs)**

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 hrs)**

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 hrs)**

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
4. Solar Photovoltaic Technology and Systems: A manual for Technicians, Trainers and Engineers, Chetan Singh Solanki, PHI Learning Pvt, 2013
5. Planning and installing photovoltaic systems-A guide for installers, architects and engineers; The German Energy Society; 2008; Second Edition; Earthscan, UK.
6. Grid-connected Solar Electric Systems, The Earthscan Expert Handbook for Planning, Design and Installation, Geoff Stapleton and Susan Neill

BBRES203: ENERGY STORAGE SYSTEMS

Total: 70 hrs

Credit: 5

Module 1 (13hrs)

Energy Storage

Need of energy storage- Different modes of Energy Storage- Mechanical Energy Storage- Electrical Storage- Chemical Storage- Electromagnetic energy storage- Thermal Energy Storage.

Reference

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

Module 2 (24 hrs)

Electrochemical, electrical and magnetic energy storage systems

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

Handbook of batteries; David Linden& Thomas B. Reddy; 2002; Third Edition; McGraw-Hill Companies, Inc.

Energy Storage; Robert A. Huggins; 2010; Springer

Module 3 (14 hrs)

Sensible heat storage (SHS)

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

Reference

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

Module 4 (19 hrs)

Latent Heat Thermal Energy Storage (LHTES)

Phase Change Materials (PCMs) : Selection criteria of PCMs- Solar thermal LHTES systems- Energy conservation through LHTES systems- LHTES systems in refrigeration and air conditioning systems

Reference

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

PRACTICAL

BBRES2P02: GRID TIED SOLAR PHOTOVOLTAIC SYSTEM

Total: 112

Credit: 4

1. Demonstration of the working of Grid tied Solar system
2. Observation of Current Waveform for Linear & Nonlinear Loads and Calculations
3. Impact of Transmission Line Inductance on Voltage Quality at PCC (point of common coupling)
4. Change in THD(Total Harmonic distortion) with Change in Transmission Line Inductance
5. Power Factor Correction using Capacitor Bank and its Impact on Power Quality at PCC
6. Grid Synchronization of Solar PV Inverter and its Performance Analysis

SEMESTER III

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BBREG303	Fundamentals of Computers	3	56	4	20	80	100
BBREG304	Thermodynamics and Fluid Mechanics	3	56	4	20	80	100
BBREG305	Novel Energy Resources	3	56	4	20	80	100
BBRES304	Solar Thermal Technology - I	4	70	5	20	80	100
BBRES305	Wind Energy	4	70	5	20	80	100
BBRES3P03	Thermodynamics and Solar Thermal (P)	6	112	4	20	80	100
BBRES3P04	Fluid dynamics and Wind Energy (P)	6	112	4	20	80	100
Total				**30**	**140**	**560**	**700**

Total Credit: 30 **Skill: 18** **General: 12**

BBREG303: FUNDAMENTALS OF COMPUTERS

Total: 56 hrs

Credit: 4

Module 1: Exploring the Computer (12 hrs)

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 hrs)

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. Module IV Peripheral devices (10 Hrs) 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 hrs)

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 hrs)

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

References

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, Sixth Edition Tata McGraw Hill (2007)
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.

BBREG304: THERMODYNAMICS AND FLUID MECHANICS

Total: 56 hrs

Credit: 4

Module 1 (12 hrs)

Laws of thermodynamics:- First law of thermodynamics- second law of thermodynamics-Clausius and kelvin statement-thermodynamic processes-reversible and irreversible-Isothermal and adiabatic changes-Work done during adiabatic and isothermal expansion-Heat engine and efficiency-Carnot cycle- efficiency- Difference between heat pump and refrigerator.

Reference

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

Module 2 (15 hrs)

Transmission of Heat:- Conduction-Convection-Radiation-Thermal conductivity-Units-Rectilinear flow of heat through a rod- flow of heat through compound media- Radial flow of heat through spherical shell-flow of heat through cylindrical tube-Determination of thermal conductivity- Searle's method-Lees Method-Lee's Disc method-Conductivity of Glass.

Reference

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

Module 3 (15 hrs)

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 hrs)

Description of fluid flow-Lagrange and Eulerian approaches-Definition of path line, streamline, streak line, stream tube, Acceleration of flow- Concept of Inertia force and other forces causing motion-Derivation of Euler's equation-Modification of Bernoulli's equation-problem on Bernoulli's equation without and with losses -Flow through Orifices; classification-Hydraulic Co-efficient of an Orifice and relation between them-Equation for Co-efficient of velocity, problems-Flow Through Pipes-Venturi Meter

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.

BBREG305: NOVEL ENERGY RESOURCES

Total: 56 hrs

Credit: 4

Module 1 (14 hrs)

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

References

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

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

Module 2 (14 hrs)

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

References

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 hrs)

Ocean Energy: Ocean energy resources - Ocean energy routes - Ocean thermal energy conversion - Wave energy conversion - Tidal energy conversion

Geothermal Energy: Origin - Types of geothermal energy sites - Geothermal Power plants References

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 hrs)

Magnetohydrodynamic (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

References

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.

BBRES304: SOLAR THERMAL TECHNOLOGY – I

Total: 70 hrs

Credit: 5

Module 1 (14 hrs)

Solar radiation: 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

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

Module 2 (19 hrs)

Flat Plate Collectors: 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

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

Module 3 (19 hrs)

Solar Concentrating Collectors: 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

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

Module 4 (18 hrs)

Solar Thermal Applications: 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

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

BBRES305: WIND ENERGY

Total: 70 hrs

Credit: 5

Module 1 (26 hrs)

Basics of Wind Energy Conversion- 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- Statistical model for wind data analysis : Weibull distribution-Energy estimation of wind regimes.

Reference

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

Module 2 (14hrs)

Aerodynamics of wind turbine:

Airfoil, lift and drag characteristics- Aerodynamic theories- Axial momentum theory-Blade element theory- Strip theory- Power coefficient and tip speed ratio characteristics-Rotor design and Performance analysis

Reference

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

Module 3 (19hrs)

Wind energy conversion systems: Wind electric generators- Tower, rotor, gearbox, power regulation, safety mechanisms- Generator: Induction and synchronous generator-Grid integration- Wind pumps- Wind driven piston pumps, limitations and performance analysis

Reference

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

Module 4 (11hrs)

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- Life cycle cost analysis

Reference

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

Additional reading

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

PRACTICAL

BBRES3P03: THERMODYNAMICS AND SOLAR THERMAL

Total: 112 hrs

Credit: 4

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

BBRES3P04: FLUID DYNAMICS AND WIND ENERGY

Total: 112 hrs

Credit: 4

1. Surface tension - Capillary rise method
2. Density of a liquid - U-Tube and Hare's apparatus
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. Demonstration of system with charge controller
9. Demonstration of system with charge controller and inverter
10. Power quality of AC output of system.
11. Impact of wind speed on power output and its quality
12. Impact of load on power output and its quality

SEMESTER IV

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BBREG406	Solar Thermal Technology - II	3	56	4	20	80	100
BBREG407	Material Science	3	56	4	20	80	100
BBREG408	Environmental Education	3	56	4	20	80	100
BBRES406	Solar Photovoltaic Energy Conversion - I	4	70	5	20	80	100
BBRES407	Entrepreneurship in Solar PV	4	70	5	20	80	100
BBRES4P04	Solar Photovoltaics (P)	6	112	4	20	80	100
BBRES4OJT	OJT	6	112	4	20	80	100
Total				**30**	**140**	**560**	**700**

Total Credits: 30 Skill: 18 General: 12

BBREG406: SOLAR THERMAL TECHNOLOGY – II

Total: 56 hrs

Credit: 4

Module 1 (9 hrs)

Heat Transfer: Concepts and Definitions

Introduction-Conduction-Boundary Conditions-Overall Heat Transfer-Dimensionless Heat-Conduction Parameters-Convection-Radiation-Heat and Mass Transfer

Reference

1. Solar Energy: Fundamentals, Design, Modeling and Applications; G. N. Tiwari; 2002; Alpha Science.
2. Solar Energy Engineering; A. A. M. Sayigh; 1977; Academic Press, UK.

Module 2 (17 hrs)

Flat-Plate Collectors: Performance and Testing

Introduction-Testing of Collector-Heat Transfer Coefficients-Optimization of Heat Losses-Determination of Fin Efficiency-Thermal Analysis of Flat-Plate Collectors-Configuration of flat plate collector connection- Effect of Heat Capacity in Flat-Plate Collector-Optimum Inclination of Flat-Plate Collector-Effect of Dust in Flat-Plate Collector

Reference

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

Module 3 (15 hrs)

Evacuated solar collector

Introduction-Evacuated-Tube Cover Collector-Evacuated-Tubular Collector-Analysis of Owens-Illinois Collector-Evacuated-Tube Collector with Heat Pipe

Reference

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

Module 4 (15 hrs)

Economic Analysis

Initial and Annual costs-Definitions-Present worth calculation-Repayment of loan in equal annual instalments-Annual savings-Cumulative Savings and Life Cycle Savings-Economic analysis of add-on solar systems-Payback period-Clean development mechanism.

Reference

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

BBREG407: MATERIAL SCIENCE

Total: 56 hrs

Credit: 4

Module 1 (16 hrs)

Nanomaterials and Nanoscience: terminology- scales of nanosystems- nanoparticles : introduction-atoms to molecules-quantum dots-shrinking of bulk materials to quantum dots. Different types of nanoparticles: metal nanoparticles and monolayer substituted nanoparticles- fullerenes: synthesis and characterization- carbon nanotubes: synthesis and characterization- various approaches in nanoparticle synthesis : self-assembled monolayers, monolayer protected metal nanoparticles. electrical and optical properties of nanoparticles- electrical and optical properties of carbon nanotubes.

References

1. Nano: The Essentials, T. Pradeep, 2007, Mc Graw Hill Publishing Company, New Delhi.
2. Nanoscience and nanotechnology, V. S. Muraleedharan and A. Subramania, 2009, Ane Books Pvt. Ltd. New Delhi.
3. Nanotubes and Nanowires, C. N. R. Rao and A.Govindraj, 2005, Royal Society of Chemistry.
4. Nanotechnology, R. Booker and , E. Boysen, 2008, Wiley India Pvt Ltd
5. Nanoscale materials in chemistry, K. J. Klabunde, 2004, John Wiley and Sons.

Module 2 (12 hrs)

Applications of nanomaterials: nanocatalysis- nanolithography- nanochemical devices- optoelectronic devices- photodetectors- LEDs and lasers. nanocrystals- immunogold labeling- applications in medical diagnosis- nanobased drug delivery- nanosensors- nanomedicines- destructive applications of nanomaterials- nanomaterials in war.

References

1. Nano: The Essentials, T. Pradeep, 2007, Mc Graw Hill Publishing Company, New Delhi.
2. Nanoscience and nanotechnology, V. S. Muraleedharan and A. Subramania, 2009, Ane Books Pvt.Ltd. New Delhi.
3. Nanotubes and Nanowires, C. N. R. Rao and A.Govindraj, 2005, Royal Society of Chemistry.
4. Nanotechnology, R. Booker and , E. Boysen, 2008, Wiley India Pvt Ltd

5. Nanoscale materials in chemistry, K. J. Klabunde, 2004, John Wiley and Sons.
6. Introduction to nanotechnology, C. P. Poole Jr and F J Owens, 2009, Wiley IndiaPvt Ltd.
7. Nanotechnology: Science, Innovation and Opportunity, L. E. Foster, 2008, Pearson Education

Module 3 (15 hrs)

Natural and Synthetic Polymers

Classification of polymers: Natural, synthetic; linear, cross-linked and network; plastics, elastomers, fibres; homopolymers and copolymers. Polymerization reactions, typical examples- polyethene, polypropylene, PVC, phenol-formaldehyde and melamine-formaldehyde resins, polyamides (nylons) and polyester. Natural rubber: structure, vulcanization. Synthetic rubbers- SBR, nitrile rubber, neoprene.Biodegradability of polymers, environmental hazards.

References

1. Polymer Science, V. R. Gowariker, 2010, NewAge International.
2. Textbook of polymer science, Billmeyer F.W., 1994, Jr.John Wiley and Sons.

Module 4 (13 hrs)

Thin Film Fabrication Methods

Thin film preparation-Physical methods-Vacuum Evaporation-Electron Beam evaporation-Flash Evaporation-Sputtering-DC sputtering-Ion Beam sputtering-Chemical methods-Electro deposition-electro plating-Chemical bath-Spray Pyrolysis.

References

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

BBREG408: ENVIRONMENTAL EDUCATION

Total: 56 hrs

Credit: 4

Module 1 (15 hrs)

Objectives, Scope and Nature of Environmental Education

Meaning, definition and characteristics of environmental education - content; Importance, objectives and scope of environmental education; Factors of degradation of environment - adverse socio - economic impacts of degradation of environment. Environmental education at Primary, Secondary and Higher Education level. Constraints for implementation. National resource center for environmental education. Impact of Science and technology on environment - degradation of resources - Role of individual in conservation of natural resources- Role of information technology in environmental and human health.

References

1. Sharma, R. A. (2008). Environmental Education. Meerut: R. Lall Books Depot.
2. Sharma, B. L., & Maheswari, B. K. (2008). Education for Environmental and Human value. Meerut: R. Lall Books Depot.
3. Singh,Y. K. (2009). Teaching of environmental science. New Delhi: APH Publishing Corporation.
4. Sharma, V. S. (2005). Environmental education. New Delhi: Anmol publication.
5. Reddy, P. K.,& Reddy, N. D. (2001). Environmental Education. Hyderabad: Neelkamal publications.
6. Kelu, P. (2000). Environmental education: A conceptual analysis. Calicut: Calicut University.
7. Joy, P., & Neal, P. (1994). The handbook of environmental education: London, New Fetter Lane
8. Sharma, R. G. (1986). Environmental Education. New Delhi: Metropolitan Book Co., Pvt. Ltd.

Module 2 (15 hrs)

Environmental Pollution, Management and Protection

Meaning and definition of Environmental hazards and pollution - Types of environmental hazards and disaster - Types of pollution: Land, Air, Water, Noise, and Radiation- Greenhouse effect- Ozone layer depletion. Need for environmental management - function

and characteristics of environmental management - dimensions of environmental management.

Factors responsible for flora and fauna extinction - Measures to conserve flora and fauna.- causes for forest fire- measures of prevention

References

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

Module 3 (13 hrs)

India and Environmental Issues, Policies and Movements

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.Strategies for sustainable development in India.

References

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

Module 4 (13 hrs)

International Efforts for Environmental Protection

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.

References

1. Ian Paulford., Hugh Flowers., 2006. Environmental Chemistry at a Glance. Blackwell.
2. Marquata K. Hill. 1997. Understanding Environmental pollution. Cambridge University Press.

3. Harrison R.M. 1993. Pollution: Causes, Effects and Control. Royal Society of Chemistry.
4. Jogdand S.N., 1995. Environmental biotechnology and industrial pollution management. Himalaya Publishing House.

BBRES406: SOLAR PHOTOVOLTAIC ENERGY CONVERSION - I

Total: 70hrs

Credit: 5

Module 1 (13 hrs)

Solar Cell Fundamentals

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 (17 hrs)

Solar Cell characteristics

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 (20 hrs)

Classification of Solar Cells

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 (20 hrs)

Solar photovoltaic (PV) module, panel and array construction

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.

BBRES407: ENTREPRENEURSHIP IN SOLAR PV

Total: 70 hrs

Credit: 5

Module 1 (15 hrs)

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 hrs)

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 hrs)

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 hrs)

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 development - 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, PHI Learning Pvt, 2013
3. Entrepreneurship, Cynthia L Greene, South Western Cengage Learning

PRACTICAL

BBRES4P04: SOLAR PHOTOVOLTAICS

Total: 112

Credit: 4

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 Exel, 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.

SEMESTER V

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BBREG509	Lasers and Optical Instrumentation	3	56	4	20	80	100
BBREG510	Environment, Health and Safety in Industries	3	56	4	20	80	100
BBREG511	Project Management	3	56	4	20	80	100
BBRES508	Energy Conservation Techniques	4	70	5	20	80	100
	Elective Course	4	70	5	20	80	100
BBRES5P05	Advanced Solar Photovoltaic Lab (P)	6	112	4	20	80	100
BBRES5P06	Advanced Solar Thermal Lab - I (P)	6	112	4	20	80	100
Total				**30**	**140**	**560**	**700**

Total Credits: 30 Skill: 18 General: 12

BBREG509: LASERS AND OPTICAL INSTRUMENTATION

Total: 56 hrs

Credit: 4

Model 1 (14 hrs)

Lasers

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.

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 (14 hrs)

Applications of Lasers

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-Holography for non-destructive testing-Medical application of lasers.

Reference

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

Module 3 (14 hrs)

Fibre Optics and Optical Communication

Optical fibre- Critical angle of propagation-modes of propagation- Acceptance angle-Fractional refractive index change- Numerical Aperture- Types of Optical fibers-Normalized Frequency- pulse dispersion Attenuation-Applications- Fibre optic communication system-Advantages of Optical fibers.

Reference

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

Module 4 (14 hrs)

Optical components and their characteristics

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

Optics and optical instruments, Johnson, Dover.

BBREG510: ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES

Total: 56 hrs

Credit: 4

Module 1 (15 hrs)

Occupational Health and Hygiene

Need for developing Environment, Health and Safety systems in work places. Status and relationship of Acts, Regulations and Codes of Practice. Role of trade union safety representatives. International initiatives. 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.

References

1. Jogdand S.N., 1995. Environmental biotechnology and industrial pollution management; Himalaya Publishing House.
2. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services 2005
3. Kumar R. (Editor)., 1997. Environmental pollution and health hazards in India. Ashish Publication.
4. Ghosh G.K., 1987. Environmental pollution: a scientific dimension. Ashish Publication. Module 2 (17hrs)

Module 2 (15 hrs)

Workplace Safety and Safety Systems

Features of the satisfactory design of work premises HVAC, ventilation. 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. Procedures and precautionary measures necessary when handling hazardous substances. Contingency arrangements for events of serious and imminent danger.

References

1. Jogdand S.N., 1995. Environmental biotechnology and industrial pollution management. Himalaya Publishing House.
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995.
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 hrs)

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 organisation for health and safety. Industry specific EHS issues.

References

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

Module 4 (10 hrs)

Education and Training

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.

References

1. Reddy, P. K. & Reddy, N. D. (2001). Environmental Education. Hyderabad: Neelkamal publications.

2. Kelu, P. (2000). Environmental education: A conceptual analysis. Calicut: Calicut University.
3. Agarwal, S.P. and Aggarwal, J.C. (1996) Environmental Protection, Education and Development. New Delhi: New Concepts.

BBREG511: PROJECT MANAGEMENT

Total: 56 hrs

Credit: 4

Module 1 (13 hrs)

Introduction: Definitions- Classifications- Project Risk- Scope

Project Management: Definitions- Overview- Project Plan- Management principles applied to project management- Project management life cycles and uncertainty

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

Reference

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

Module 2 (13 hrs)

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- Academic Press, 1995
2. The Essentials of Project Management-Dennis Lock-Gower Publishing Ltd., 2014
3. Project management - David I Cleland - Mcgraw Hill International Edition, 1999
4. Project Management-Harvey-Maylor-Pearson Publication, 2009

Module 3 (15hrs)

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- Academic Press, 1995
2. The Essentials of Project Management-Dennis Lock-Gower Publishing Ltd., 2014
3. Project management - David I Cleland - Mcgraw Hill International Edition, 1999
4. Project Management-Harvey-Maylor-Pearson Publication, 2009

Module 4 (15 hrs)

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

Project Inventory Management: Nature of project inventory- Supply and transportation of materials- Use of PERT & CPM techniques

Reference

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

BBRES508: ENERGY CONSERVATION TECHNIQUES

Total: 70 hrs

Credit: 5

Module 1 (18 hrs)

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.

References

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 hrs)

Energy Conservation Methods in Electrical System

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

References

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 hrs)

Energy Conservation In Thermal System

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

References

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 hrs)

Energy Conservation in Housing & Commercial Building

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

References

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 guidebook.
3. Energy Efficiency in Electrical Utilities, 2010, BEE guidebook.

ELECTIVE COURSES

BBRES5E01: SOLAR PHOTOVOLTAIC ENERGY CONVERSION – II

Total: 70hrs

Credit: 5

Module 1 (15 hrs)

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)

References

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 hrs)

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)

References

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 hrs)

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.

References

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 hrs)

Photovoltaic System Design and applications - Introduction to Solar PV systems, Stand alone 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.

References

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.

BBRES5E02: SOLAR THERMAL TECHNOLOGY - III

Total: 70 hrs

Credit: 5

Module 1 (15 hrs)

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

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

Module 2 (20 hrs)

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

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

Module 3 (20 hrs)

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

Textbook

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

Module 4 (15 hrs)

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

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

PRACTICAL

BBRES5P05: ADVANCED SOLAR PHOTOVOLTAIC LAB

Total: 112 hrs

Credit: 4

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.

BBRES5P06: ADVANCED SOLAR THERMAL LAB - I

Total: 112 hrs

Credit: 4

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.

SEMESTER VI

Course Code	Title of the Course	Instructional hours/week	Instructional hours for the course	Credits	ISA	ESA	Total
BBREG612	Spectroscopy - Experimental Techniques	3	56	4	20	80	100
BBREG613	Power Electronics	3	56	4	20	80	100
BBREG614	Fuel Cells and Hydrogen	3	56	4	20	80	100
BBRES609	Energy Management and Auditing	4	70	5	20	80	100
BBRES6P07	Advanced Solar Thermal Lab - II (P)	6	112	4	20	80	100
BBRES6P08	Experimental Techniques and Power Electronics (P)	6	112	4	20	80	100
BBRES6PJ	Project		140	5	20	80	100
Total				**30**	**140**	**560**	**700**
Grand Total				**180**			**4100**

Total Credits: 30 Skill: 18 General: 12

BBREG612: SPECTROSCOPY - EXPERIMENTAL TECHNIQUES

Total: 56 hrs

Credit: 4

Module 1 (13 hrs)

Spectroscopy

Atom models- Thomson's model-Rutherford's nuclear atom model-Bohr atom model-Somerfield's relativistic atom model- vector atom model- Fine structure of Hydrogen atom - Rotational and vibrational spectra of rigid diatomic molecules- Raman effect-quantum theory

Reference

Introduction to Modern Physics- H.S. Mani and G.K. Mehta

Module 2 (13 hrs)

Spectroscopic techniques

Qualitative ideas of: Fourier Transform Infrared Spectroscopy, UV-Vis-NIR spectroscopy, Photoluminescence technique, Raman spectroscopy, X-ray Photoelectron Spectroscopy

Reference

Semiconductor material and device characterization; Dieter K. Schroder; 2006; Wiley-Interscience.

Module 3 (15 hrs)

Vacuum Techniques

Vacuum Physics: Important and fields applications of vacuum, gas properties, gas flow regimes, gas transport properties, gas conductance of apertures, elbows, tubes etc. for viscous and molecular flow regimes, principles of pumping concepts (vacuum pumps), vacuum measurement, leak detection, source of gases in vacuum system, evaluation of gas load, vacuum system design.

Reference

Vacuum technology; A. Roth; 1990; Elsevier Science.

Module 4 (15 hrs)

Qualitative ideas of: Basic optical microscopy-Electron microscopy: SEM and TEM-Probe Microscopy: STM, AFM-Diffraction techniques: XRD-Thermal analysis: Thermo-gravimetric analysis (TGA).

Reference

Semiconductor material and device characterization; Dieter K. Schroder; 2006; Wiley-Interscience.

BBREG613: POWER ELECTRONICS

Total: 56 hrs

Credit: 4

Module 1 (13 hrs)

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

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

Module 2 (13 hrs)

Thyristors, SCR, DIAC, TRIAC

Basic ideas and Types of Thyristors-Silicon Controlled Rectifier (SCR)-biasing-operation-equivalent circuit-Characteristics-SCR ratings-Series and parallel combination of SCR-Applications- Basic construction of Diac- V-I characteristic- Applications-TRIAC-Operation- V-I characteristics-TRIAC ratings-Applications

Reference

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

Module 3 (15 hrs)

UJT and SCS

Uni Junction Transistor (UJT)-construction-equivalent circuit-intrinsic standoff ratio-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

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

Module 4 (15 hrs)

Controlled Rectifiers

Introduction-SCR - Power control using SCR - SCR half wave rectifier - Average values of load voltage and current - 90°Variable Half Wave Rectifier - 180° Variable Half Wave Rectifier - SCR Full Wave Rectifier - UJT Triggered SCR phase control -TRIAC power control - DIAC-TRIAC Phase Control Circuit - General ideas of Inverters- Single phase inverter - Push-pull inverter.

Reference

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

BBREG614: FUEL CELLS AND HYDROGEN

Total: 56 hrs

Credit: 4

Module 1 (10 hrs)

Fuel Cells: History - Need for fuel cells- Applications- principle - working - thermodynamics and kinetics of fuel cell process -performance evaluation of fuel cell - comparison on battery Vs fuel cell

References

1. Fuel Cells: Theory and Application; Hart, A.B and G.J. Womack; 1989; First Edition; Prentice Hall.
2. Fuel Cell and Their Applications; Kordesch, K and G. Simader; 1996; First Edition; Wiley-VCH, Germany.
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005; Illustrated Edition Elsevier Academic Press, UK.
4. Hydrogen Energy: Challenges and Prospects; David Anthony James Rand and Ronald Dell; 2008; The Royal Society of Chemistry, UK.

Module 2 (16 hrs)

Fuel Cell Types: Types of fuel cells - Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Solid Oxide Fuel Cell, Molten Carbonate Fuel Cell, Direct Methanol Fuel Cell, Proton-exchange Membrane Fuel Cell.

References

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

Module 3 (20 hrs)

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

References

1. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005; Illustrated Edition Elsevier Academic Press, UK.
2. Hydrogen Energy: Challenges and Prospects; David Anthony James Rand and Ronald Dell; 2008; The Royal Society of Chemistry, UK.

Module 4 (10 hrs)

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

References

1. Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005; Illustrated Edition Elsevier Academic Press, UK.
2. Hydrogen Energy: Challenges and Prospects; David Anthony James Rand and Ronald Dell; 2008; The Royal Society of Chemistry, UK.

BBRES609: ENERGY MANAGEMENT AND AUDITING

Total: 70 hrs

Credit: 5

Module 1 (15 hrs)

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 (15 hrs)

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 (20 hrs)

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 (20 hrs)

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

PRACTICAL

BBRES6P07: ADVANCED SOLAR THERMAL LAB - II

Total: 112 hrs

Credit: 4

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

BBRES6P08: EXPERIMENTAL TECHNIQUES AND POWER ELECTRONICS

Total: 112 hrs

Credit: 4

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

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