Curriculum for

B.Voc./D.Voc.

in

Solar System Technology

1. Introduction

All India Council for Technical Education (AICTE) Ministry of HRD, Government of India has introduced Entrepreneurship oriented Skill development courses of B.Voc. /D. Voc. /Skill Diploma. These courses will be run by AICTE approved institutes by using available infrastructure and facilities. In these courses the institute will conduct general education content and sector specific skills will be imparted by Skill Knowledge Providers/ Training Providers/ Industries.

Key Features:

Objectives

- To provide judicious mix of skills relating to a profession and appropriate content of General Education.
- To ensure that the students have adequate knowledge and skills, so that they are work ready at each exit point of the programme.
- To provide flexibility to the students by means of pre-defined entry and multiple exit points.
- To provide vertical mobility to students admitted in such vocational courses.
- The certification levels will lead to Diploma/Advanced Diploma/B. Voc. Degree in Solar Engineering Technology and will be offered by respective affiliating University/Board of Technical Education.
- Students may be awarded Certificate/Diploma/Degree as out-lined in the Table below:

Award	Duration after class XII
Certificate	6months
Diploma	1 Year
Advanced Diploma	2 Year
B.Voc Degree	3 Year

2. Course Objectives

After successfully completing the vocational course, the student would have acquired relevant appropriate and adequate technical knowledge together with the professional skills and competencies in the field of Solar System so that he/she is properly equipped to take up gainful employment in this Vocation. Thus he/she should have acquired.

A. Understanding of

(a) The relevant basic concepts and principles in basic science subjects (Physics, Chemistry and Mathematics) so that he/she is able to understand the different vocational subjects.
(b) The basic concepts in engineering workshops.
(c) The concepts, principles of working of solar systems.
(d) The knowledge of testing procedure of components used in solar systems and making use of different test instruments.

(e) The procedure of installing the solar systems.
(f) The concepts and principles used in Solar Systems and its maintenance.

B. Adequate Professional Skills and Competencies in

(a) Selecting the material required for solar system and its layout.
(b) Testing the performance of Solar Systems.
(c) Locating the fault at component level and at the stage level.

C. A Healthy and Professional Attitude so that She/he has

(a) An analytical approach while working on ajob.
(b) An open mind while locating/rectifying faults.
(c) Respect for working with his/her own hands.
(d) Respect for honesty, punctuality and truthfulness

3. Course Structure

The course will consist of combination of practice, theory and hands on skills in the Solar Engineering sector.

Curriculum

The curriculum in each of the years of the programme would be a suitable mix of general education and skill development components.

Skill Development Components:

- The focus of skill development components shall be to equip students with appropriate knowledge, practice and attitude, to become work ready. The skill development components will be relevant to the industry as per its requirements.
- The curriculum will necessarily embed within itself, National Occupational Standards (NOSs) of specific job roles within the industry. This would enable the students to meet the learning outcomes specified in the NOSs.
- The overall design of the skill development component along with the job roles selected will be such that it leads to a comprehensive specialization in few domains.
- The curriculum will focus on work-readiness skills in each of the year of training.
- Adequate attention will be given in curriculum design to practical work, on the job training, development of student portfolios and project work.

General Education Component:

- The general education component adheres to the normal senior secondary and university standards. It will emphasize and offer courses which provide holistic development. However, it will not exceed 40% of the total curriculum.
- Adequate emphasis is given to language and communication skills.

Curriculum

Semester	Code	Educational Component	L	T	P	No of hours/week	Credit	Marks
I		**Theory**						
	SST.101	Basics of Mathematics	4	0	0	4	4	50
	SST.102	Communication Skills(Reading and Writing)	4	0	0	4	4	50
	SST.103	Basics of Computers	4	0	0	4	4	50
	SST.104	Solar Energy System	4	0	0	4	4	50
		Practical						
	SST.105	Solar Technology-1	2	0	0	2	2+2	50
		Training						
	Operation and Maintenance of solar plant		4 weeks				10	150
II		**Theory**						
	SST.201	Spoken English	4	0	0	4	4	50
	SST.202	Entreprenuership Development	4	0	0	4	4	50
	SST.203	Drug Abuse : Problem, Management and Prevention	4	0	0	4	4	50
	SST.204	Solar Photovoltaic Power Plants	4	0	0	4	4	50
		Practical						
	SST.205	Solar Technology-2	2	0	0	2	2+2	50
		Training						
	Solar Installation Field Technician		6 weeks				10	150

Detailed Curriculum

(Semester I)

(SST.101) Basics of Mathematics

Course Outcomes – After the completion of this course, students will be :

1 Be able to perform basic computations
2 Be able to write and understand basic proofs.
3 Develop and maintain problem-solving skills.
4 Use **mathematical** ideas to model real-world problems.

Module 1 –Matrices: Concept, notation, order, equality, types of matrices, zero and identity matrix, transpose of a matrix, symmetric and skew symmetric matrices. Operation on matrices: Addition and multiplication and multiplication with a scalar. Simple properties of addition, multiplication and scalar multiplication. Non-commutativity of multiplication of matrices and existence of non-zero matrices whose product is the zero matrix (restrict to square matrices of order 2).Concept of elementary row and column operations.

Module 2 -Trigonometric Functions: Positive and negative angles. Measuring angles in radians and in degrees and conversion of one into other. Definition of trigonometric functions with the help of unit circle. Truth of the sin2x+cos2x=1, for all x. Signs of trigonometric functions. Domain and range of trigonometric functions and their graphs. Identities related to sin2x, cos2x, tan2 x, sin3x, cos3x and tan3x.

Module 3 -Limits and Derivatives: Derivative introduced as rate of change both as that of distance function and geometrically. Intuitive idea of limit. Limits of polynomials and rational functions trigonometric, exponential and logarithmic functions. Definition of derivative relate it to scope of tangent of the curve, derivative of sum, difference, product and quotient of functions. Derivatives of polynomial and trigonometric functions.

Module 4 –Integrals: Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts. Definite integrals as a limit of a sum, Fundamental Theorem of Calculus (without proof). Basic properties of definite integrals and evaluation of definite integrals. Applications in finding the area under simple curves, especially lines, circles/ parabolas/ellipses.

References:

- Mathematics, *NCERT-XI (*Volume- 1) & (Volume-2)
- Mathematics, *NCERT-XII (*Volume-1) &(volume-2)
- Mathematics by *R D Sharma,*Dhanpat Rai Publications
- Mathematics *by J.P.Mohindru ;*Modern publications
- Mathematics *by Romesh Kumar;* Pardeep publications

(SST.102) Communication Skills (Reading and Writing)

Course Outcomes – After the completion of this course, students will be :

1 Be able to adopt strategies for effective reading
2 Be able to write formal and informal letters
3 Be able to write official reports.
4 Be able to deliver professional presentations.

Syllabus

1. Reading comprehension.
2. Letter writing: Various types of letters formal e.g. letter to the editor or director of your institute and informal e. g letters to friends & family members.
3. Paragraph writing.
4. Making notes, using Abbreviations and symbols in note making.
5. Paraphrasing.
6. Writing reports- Business, Official.

References:

- Practical English Usage. Michael Swan. OUP. 1995.
- Remedial English Grammar. F.T. Wood. Macmillan.2007
- On Writing Well. William Zinsser. Harper Resource Book. 2001
- Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
- Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press. 2011

(SST.103) Basics of Computers

Course Outcomes – After the completion of this course, students will be able to :

1. Learn Basic Applications of Computer and its component
2. Know Fundamentals of computer sciences get knowledge of Hardware & Software, open Source Technologies etc.
3. Learn about various computational tools internet and email etc.
4. Know Computer Virus, Anti-Virus, Terms and Abbreviation used in IT.

Module 1 : Introduction and Objectives, Basic Applications of Computer and its component.

Module 2 : Bringing computer to life, Fundamentals of computer sciences, Hardware & Software, Concept of Open Source Technologies, Input & output Devices.

Module 3 : Knowledge of MS Word, MS Excel, MS Access, MS PowerPoint, PDF Internet and E-mail.

Module 4 : Concept of Computer Virus and Latest Anti-Virus, Terms and Abbreviation used in IT.

References/Books

- Basic Computer Course by *C S Changeriya*.
- Computer Basics by *Bittu Kumar*.
- Fundamentals of Computers by V. Rajaraman
- Fundamentals of Computers by E Balagurusamy
- Computer Hardware: Installation, Interfacing, Troubleshooting and Maintenance by James K.L

(SST.104) Solar Energy System

Course Outcomes – After the completion of this course, students will be able to :

1. Get familiar with basic principles of solar technology & solar photovoltaic cells.
2. Learn about Solar Radiation , solar spectrum, optimal tilt for solar equipment, monthly averaged global radiation etc,
3. Get knowledge of Fundamentals of Solar Cells , I-V Characteristics Solar Cell parameters ,conversion efficiency and power output of solar cell
4. Know about Solar Photovoltaic Lighting System, Lead-Acid Batteries ,Maintenance of Battery, Cleanliness etc.

Module I : Basic Principles in Solar Technology: Solar Thermal Conversion: Principles of Solar Radiation, Solar Collector, Absorption of radiation and Conversion to Thermal Energy, Collection & Storage of Thermal Energy, Solar Photovoltaic Cells.

Module II : Solar Radiation: Solar Spectrum, Extra-terrestrial Radiation, Radiation on the Earth Surface, Global, Direct and Diffuse Solar Radiation, Solar Radiation at a Given Location, Annual Variation in Solar Radiation, Optimal Tilt for Solar Equipment, Monthly Averaged Global Radiation at Optimal Tilt.

Module III: Fundamentals of Solar Cells : Characteristics of semiconductors, Differences between semiconductors, insulators and conductors ,Theory of p n junction, Principle of operation of p-n junction Solar Cell, I-V Characteristics Solar Cell parameters ,Voc, Isc, FF ,conversion efficiency and power output of solar cell.

Module IV : Solar Photovoltaic Lighting System: Principle of Photovoltaic lighting system, Solar Array, Battery Bank, Electronic Controller, Inverter, Solar photovoltaic street lighting system, Maintenance of Battery, Cleanliness, Adding water, Kind of water, Discharge limits, Basics of Lead-Acid Batteries, Discharge limits of Lead-Acid batteries.

References/Books:

- Renewable Energy Technologies: A Practical Guide for Beginners, Chetan Singh Solanki, PHI|School Books (2008)
- Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki PHI; 3 edition 2015

- Renewable Energy Sources and Emerging Technologies, Kothari D.P. and Singal K. C, New Arrivals - PHI; 2 edition (2011)
- Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Chetan Singh Solanki PHI (1 January 2013)
- Fundamentals of Renewable Energy Systems Paperback – D. Mukherjee, New Age International Publisher; First edition (2011)
- Science & Technology of Photovoltaics P Jayrama Reddy, BS Publications ,CRC Press 2010

SST.105 – Solar Technology-1

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Recognize/use basic solar technology.
2. Develop a comprehensive technological understanding in solar PV system components.
3. Provide adequate inputs on a variety of issues in solar technology.
4. Acquire training in solar technology.

Lectures/Demonstrations:

1. Basics of electrical systems such as current, voltage, power, Ohm's law, series and parallel connections etc.
2. Basic measuring instruments such as voltmeter, ammeter, wattmeter and energy meter & their use.
3. Cells and batteries.
4. Diodes and solar cells.
5. Solar PV modules, their measurements and connections.
6. Solar photovoltaic system and its applications.

Experiments

1. Verification of Ohm's Law.
2. Series and parallel connection of cells in circuits.
3. Charging and discharging of a lead-acid battery.
4. Current and voltage measurement using ammeter and voltmeter.
5. Power and energy measurement using wattmeter and energy meter.
6. V-I characteristics of a diode.
7. Familiarization with solar energy gadgets.
8. To determine voltage and current of solar cells.
9. Demonstration of solar panels.
10. Identifying and measuring the parameters of a solar PV module.
11. Series and parallel connection of PV modules.
12. Study of applications of solar photovoltaic system.

Recommended Books

1. Renewable energy Technologies: A practical Guide for Beginners, Chetan Singh Solanki, PHI School Books (2008).
2. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki,PHI; 3 edition 2015.
3. Solar Photovoltaic Technology and systems: A Manual for Technicians, trainers and Engineers, Chetan singh Solanki, PHI 2011.
4. Fundamentals of Renewable Energy Systems Paperback- D. Mukherjee, New Age International Publishers; First edition(2011).

(Semester II)

(SST.201) Spoken English

Course Outcomes – After the completion of this course, students will be able to –

5. Frame grammatically correct sentences in English.
6. Fluently speak in English in many situations.
7. Able to present thought's more effectively.
8. Able to translate between different languages.

Module 1: Basic English Grammar

Parts of speech and their uses, Word formation, Tenses and their Uses, Articles and their uses, Types of sentences and sentence patterns, Synonyms and their uses, Antonyms and their uses.

Module 2: Conversation in English

Greeting, Introducing Oneself, Invitation, Making Request, Expressing Gratitude, Complimenting and Congratulating, Expressing Sympathy, Apologizing, Asking for Information, Seeking Permission, Complaining and Expressing Regret

Module 3: Using English in Real Life Situation

At the Bank/ post office/ College office, At the Green Grocer, At the Temple, At the College Canteen or Restaurant, At the Police station, At the Railway Station/ Bus Station, At the Medical Shop, At the Library, Interviews, Booking a Room in a Hotel

Module 4: Translation

Translation from PUNJABI/HINDI to English

Books –

- 'Basic Grammar in Use' by Raymond Murphy, *Cambridge University*
- 'English Grammar Workbook' by Wendy Wilson and James H. Barlow, *Kindle Edition, 2020*
- 'Handbook of English Translation (Punjabi-English)' by Balwant Kaur and Pratap Rastogi, *Ramesh Publishing House, 2021*
- 'High School English Translation' by Sharma R K, *LUCENT'S Publications, 2020.*

(SST.202) Entrepreneurship Development

Module-I :Introduction to Entrepreneurship

Definition of Entrepreneur, Entrepreneurial Traits, and Entrepreneur vs. Manager, Entrepreneur vs. Entrepreneur. The Entrepreneurial decision process. Role of Entrepreneurship in Economic Development, Ethics and Social responsibility of Entrepreneurs. Opportunities for Entrepreneurs in India and abroad. Womanas Entrepreneur.

Module-II : Creating and Starting the Venture

Sources of new Ideas, Methods of generating ideas, creating problem solving, product planning and development process.

Module-III : The Business Plan

Nature and scope of Business plan, Writing Business Plan, Evaluating Business plans, Using and implementing business plans. Marketing plan, financial plan and the organizational plan,Launching formalities.

Module – IV : Financing and Managing the new venture

Sources of capital, Record keeping, recruitment, motivating and leading teams, financial controls. Marketing and sales controls. E-commerce and Entrepreneurship, Internet advertising.

References:

- Entrepreneurial Development, Khanka S.S, S.Chand ,2006.
- Entrepreneurship development, Sangeeta Sharma, 2016.
- Entrepreneurship Development, S.Anil Kumar, 2008.

(SST.203) Drug Abuse : Problem, Management and Prevention

Module I : Problem of Drug Abuse: Concept and Overview: What are drugs and what constitutes Drug Abuse?Prevalence of menace of Drug Abuse, How drug Abuse is different from Drug Dependence and Drug Addiction?Physical and psychological dependence- concepts of drug tolerance
Introduction to drugs of abuse: Short Term, Long term effects & withdrawal symptoms: Stimulants; Amphetamines, Cocaine, Nicotine.**Depressants**; Alcohol, Barbiturates- Nembutal, Seconal, Phenobarbital Benzodiazepines –Diazepam, Alprazolam, Flunitrazepam.Narcotics; Opium, morphine, heroin. Hallucinogens; Cannabis & derivatives (marijuana, hashish, hash oil).

MODULE II : Nature of the Problem: Vulnerable Age Groups,Signs and symptoms of Drug Abuse ;Physical indicators, Academic indicators, Behavioral and Psychological indicators

MODULE III : Causes and Consequences of Drug Abuse: Causes; Physiological, Psychological, Sociological.Consequences of Drug Abuse; For individuals ,For families, For society & Nation

MODULE IV : Management & Prevention of Drug Abuse: Management of Drug Abuse, Prevention of Drug Abuse, Role of Family, School, Media, Legislation&De-addictionCenters

References:

- Kapoor.T. (1985) Drug Epidemic among Indian Youth, New Delhi: Mittal Pub
- Modi, Ishwar andModi, Shalini (1997) Drugs: Addiction and Prevention,Jaipur: Rawat Publication.
- Ahuja, Ram,(2003),Social Problems in India, Rawat Publications: Jaipur
- 2003 National Household Survey of Alcohol and Drug Abuse. New Delhi, Clinical Epidemiological Unit, All India Institute of Medical Sciences,2004.
- World Drug Report 2011, United Nations Office of Drug and Crime.
- World Drug Report 2010, United nations Office of Drug and Crime.

- Extent, Pattern and Trend of Drug Use in India, Ministry of Social Justice and Empowerment, Government of India,2004.
- The Narcotic Drugs and Psychotropic Substances Act, 1985, (New Delhi: Universal, 2012)

(SST.204) Solar Photovoltaic Power Plants

Course Outcomes – After the completion of this course, students will be able to –

- Understand basics of Solar Modules and Arrays
- Understand the working of solar plants
- Understand the grid connections with solar plants
- Learn about the applications of solar panels

Module 1 – Solar Modules and Arrays: Characteristics, Classification, Construction of module, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies.

Module 2 - Solar Thermal Power Plants: Working of a typical Concentrated Solar Power (CSP) plant Maintenance procedure of CSP systems

Module 3 - Solar Photovoltaic (PV) Power Plants: Working of a typical Solar PV Power plant, types of Batteries for solar PV system, Maintenance procedure of typical Solar PV Power plant.

Module 4 - Grid Connection of Solar Power Plants - Grid connection of CSP plants, Grid connection of Solar PV power plants.

Reference books

- S. P. Sukhatme and J.K. Nayak, Solar Energy –Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.

- Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

- Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

(SST.205) Solar Technology-2

Course Outcomes – At the end of this course, students will demonstrate the ability to –

- Understand the concept of Solar PV module and its parameters
- Design the model of solar module on software platform
- Understand the effect of parameters on solar panel performance
- Learn about the connections of Grid connected Solar system

Lectures/Demonstrations –

1. Concepts related to Solar PV systems – Voltage, Current, Power and Solar insolation
2. Connections of Solar PV module to converter circuit and battery bank
3. Solar PV system characteristics with varying values of solar insolation
4. Designing of solar cell and module on software platform.
5. Measurements of various parameters of a Solar PV plant
6. Understanding of grid connections with solar plant

List of Experiments

1. To study about the configuration of solar PV system
2. To plot the V-I characteristics of solar PV system
3. To plot the power characteristics of solar PV system
4. To analyze the effect of temperature on solar output voltage and current
5. To analyze the effect of temperature on solar output power
6. To study the operation of battery charge using a PV module
7. To study the effect of partial shading on PV panel operation
8. To plot solar panel performance versus insolation
9. To study sun tracking system in solar panels
10. To take readings using Pyranometer
11. To take readings of various parameters from a grid connected solar plant

Teaching Scheme for 3rd to 4th semester

B.Voc. in

Solar System Technology

Teaching Scheme

Semester	Code	Educational Component	L	T	P	H	Credit	Marks
III		**Theory**						
	SST.301	Soft Skills	3	0	0	3	3	50
	SST.302	Basics of programming-I	3	0	0	3	3	50
	SST.303	Solar Cell and Photovoltaic Technologies	4	0	0	4	4	50
	SST.304	Solar Energy Storage and Management	4	0	0	4	4	50
		Practical						
	SST.305	Programming Lab-I	0	0	2	4	2	50
	SST.306	Electrical Technology Lab	2	0	2	4	2+2	50
		On-Job-Training (OJT)*						
	PV Installation and Maintenance						10	200
IV		**Theory**						
	SST.401	Environmental Education	4	0	0	4	4	50
	SST.402	Solar Photovoltaic system installation and maintenance	3	0	0	3	3	50
	SST.403	Engineering Graphics and Drawing	4	0	0	4	4	50
	SST.404	Solar Photovoltaic system design and integration	3	0	0	3	3	50
		Practical						
	SST.405	Solar Technology Lab	0	0	2	4	2	50
	SST.406	Electrical Technology Lab	2	0	2	4	2+2	50
		On-Job-Training (OJT)*						
	Solar Power Plant Calculation & Design						10	200

*The Students are to undergo 180 hrs training in house/ industry/ Skill Knowledge Provider (SKP)/ Sector Skill Council(SSC) during the progress of the semester on week-ends or winter/summer vacation and submit a training report on completion of training.

Syllabus 3rd Semester

(SST.301) SOFT SKILLS

Course Outcomes – After the completion of this course, students will be able to

- Achieve basic awareness about the significance of soft skills in professional and interpersonal communications
- Facilitate an all-round development of personality
- Develop his/her personal traits
- Expose their personality effectively

Module I – Soft Skills

Introduction to Soft Skills, Aspects of Soft Skills, Identifying your Soft Skills, Importance of Soft Skills, SWOT Analysis.

Module II - Forming Values

Values and Attitudes, Importance of Values, Self-Discipline, Personal Values - Cultural Values-Social Values-some examples, Recognition of one's own limits and deficiencies.

Module III – Email Writing

Email writing Skills, definition, examples, format and samples.

Module IV - Etiquette and Manners

ETIQUETTE- Introduction, Modern Etiquette, Benefits of Etiquette, Do's and Don'ts for Men and Women. MANNERS- Introduction, Importance of manners at various occasions, Professional manners, Mobile manners.

Reference books

- Butterfield, Jeff, 'Soft Skills for Everyone', Cengage Learning, New Delhi, 2010.
- G.S. Chauhan and Sangeeta Sharma, 'Soft Skills', Wiley, New Delhi, 2016.
- Klaus, Peggy, Jane Rohman & Molly Hamaker, 'The Hard Truth About Soft Skills', Harper Collins E-books, London, 2007.
- S.J. Petes, Francis, 'Soft Skills and Professional Communication', Tata McGraw Hill Education, New Delhi, 2011.

(SST.302) Basics of Programming- I

Course Outcomes – After the completion of this course, students will be able to

- Learn features of MATLAB as a programming tool.
- Promote new teaching model that will help to develop programming skills and technique to solve mathematical problems.
- Understand MATLAB graphic feature and its applications.
- Use MATLAB as a simulation tool.

Module I – Introduction to MATLAB
The MATLAB Environment, MATLAB Basics – Variables, Numbers, Operators, Expressions, Input and output. , Vectors, Arrays – Matrices

Module II – MATLAB Functions
Built-in Functions, User defined Functions.

Module III – Programming with MATLAB
Conditional Statements, Loops, MATLAB Programs – Programming and Debugging. Applications of MATLAB Programming.

Module IV – Basics of Python Programming
Introduction, python features, python variables, types of operators.

Reference books

- "A Guide to MATLAB - for Beginners and Experienced Users", 2nd Ed., Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, Cambridge University Press, (2006).
- "Essentials of MATLAB Programming", 2nd Ed., Stephen J. Chapman, Cengage Learning, (2009).
- "MATLAB Demystified", David McMahon, The McGraw-Hill Companies, (2007).
- "The Complete Refrence : Python " , Martin C. Brown, Mc Graw Hill Publication.

(SST.303) Solar Cell and Photovoltaic Technologies

Course Outcomes – After the completion of this course, students will be able to:

- Get familiar with basic principles of solar cells & PV modules.
- Learn about Solar Radiation.
- Get knowledge of fundamentals of flate-plate collectors.
- Know about solar cooker.

Module I: Solar Cells & PV modules

Solar cell types, equivalent circuit diagrams of solar cells, efficiency of solar cells and PV modules, solar photovoltaic systems & components.

Module II: Solar Radiation

Solar angles, day length, angle of incidence on titled surface, sunpath diagrams, shadow determination, extraterrestrial characteristics, and effect of earth atmosphere.

Module III: Solar Collectors

Flat-plate collectors and concentrating type collectors.

Module IV: Applications of Solar Energy

Solar cooker, solar pond, solar passive heating and cooling systems, greenhouse technology.

References/Books:

- Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki PHI; 3 edition 2015.
- Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Chetan Singh Solanki PHI (1 January 2013).
- Science & Technology of Photovoltaics P Jayrama Reddy, BS Publications, CRC Press 2010.
- From Sunlight to Electricity: A Practical Handbook on Solar Photovoltaic Applications, Suneel Deambi, The Energy and Resources Institute, TERI (30 January 2009).

(SST.304) SOLAR ENERGY STORAGE AND MANAGEMENT

Course Outcomes – After the completion of this course, students will be able to:

- Get familiar with basic principles of solar energy storage.
- Learn about Solar Battery storage.
- Get knowledge of fundamentals of mechanical storage.
- Know about thermal storage.

Module I: Grids
Need of storage, Types of solar energy storage system-Grid tied, grid/hybrid and off grid. Advantages and disadvantages.

Module II: Battery management & storage
Introduction, types of batteries and their working, battery capacity and other specifications, battery management, maintenance & testing of batteries.

Module III: Mechanical Storage
Introduction, Types, flywheel storage, pumped hydro storage, compressed-air storage.

Module IV: Thermal Storage
Introduction, types of thermal storage-two-tank direct system, two-tank indirect system, and single-tank thermocline system.

References/Books:

- R. Huggins, “Energy Storage”, Springer science and business media, 2010.
- Y. Wu, “Lithium-Ion Batteries: Fundamentals and Applications (Electrochemical Energy Storage
  and Conversion)”, CRC Press, 2015.
- T. M. Letcher, “Storing Energy: with Special Reference to Renewable Energy Sources”, Elsevier
  science, 2016.
- P. T. Moseley, and J. Garche, “Electrochemical Energy Storage for Renewable Sources and Grid
  Balancing”, Newnes, 2014.
- D. Wang, and G. Cao, “Nanomaterials for Energy Conversion and Storage”, World Scientific
  Publishing Company, 2017

(SST.305) Programming Lab-I

Course Outcomes- At the end of this course, students will demonstrate the ability to-

- Understand the concept of MATLAB.
- Understand the concept of MATLAB-SIMULINK.
- Develop basic programmes using python.

List of Experiments

1. Introduction to MATLAB, Creating variables, some useful MATLAB Functions, Data Types.
2. Introduction to Graphing Functions Using MATLAB
3**.** Input and Output Statements
4.Conditional Statements, Introduction to Loops, Nested Loops and the Break Statement
5. Arrays & Array Functions
6. Introduction to MATLAB-SIMULINK.
7. Matlab/SIMULINK model of a photovoltaic cell.
8. Introduction to python programming.
9. To compute the GCD of two numbers using python.
10. To find the square root of a number using python.

(SST.306)Electrical Technology Lab

Course Outcomes- At the end of this course, students will demonstrate the ability to-

- Understand the use and importance of various types of equipments used in the laboratory.
- Understand the working of diode and rectifiers.
- Understand the working of transistor in various configurations.
- Understand the operation of amplifiers and oscillators.

Lectures/Demonstrations

1. V-I characteristics of PN diode.
2. Construction and working of rectifiers (Half wave & full wave).
3. Zener diode as voltage regulator.
4. Construction and working of transistor, transistor configurations (CB, CE & CC).
5. Voltage and power amplifiers.
6. Basics of oscillators.

List of Experiments

1. To plot V-I characteristics of PN diode.
2. To study the operation of half wave rectifier.
3**.** To study the operation of mid-point full wave rectifier.
4. To study the operation of bridge type full wave rectifier.
5**.** To study the operation of Zener diode voltage regulator.
6. To draw the input-output characteristics of CB transistor.
7. To draw the input-output characteristics of CE transistor.
8. To draw the input-output characteristics of CC transistor.
9. To study the operation of voltage and power amplifier.
10. To study the working of oscillator and to observe the waveforms using CRO.

Syllabus 4th Semester

(SST.401) Environmental Education

Course Outcomes – After the completion of this course, students will be able to:

- Get familiar with natural resources and environment.
- Learn about biodiversity.
- Get knowledge of the degradation of environment and its impacts.
- Know about the conservation of environment.

Module I: Environment and Natural Resources
Natural resources, Growing energy needs, Role of an individual in conservation of natural resources Multidisciplinary nature of environmental education.

Module II: Biodiversity
Definition; importance of Biodiversity, Threats to biodiversity: Natural calamities, habitat destruction and fragmentation, over exploitation, hunting and poaching.

Module III: Environmental degradation and impacts
Human population growth and its impacts on environment; land use change, land degradation, soil erosion and desertification. Use and over-exploitation of surface and ground water, construction of dams, floods, conflicts over water (within India). Deforestation: Causes and effect.

Module IV: Conservation of Environment
Concept of sustainability and sustainable development with judicious use of land, water and forest resources; afforestation. Control measures for various types of pollution; use of renewable and alternate sources of energy. Solid waste management: Control measures of urban and industrial waste.

References/Books:

- ErachBarucha (2004) Text book of Environmental Studies for Undergraduate courses (Prepared for University Grants Commission) Universities Press.
- Purnima Smarath (2018) Environmental studies Kalyani Publishers, Ludhiana
- Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India, Email:mapin@icenet.net (R)
- Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p
- Clark R.S., Marine Pollution, Clanderson Press Oxford (TB)
- Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumbai, 1196p

(SST. 402) Solar Photovoltaic System Installation and Maintenance

Course Outcomes – After the completion of this course, students will be able to:

- Get familiar with solar photovoltaic system.
- Learn about solar inverters.
- Get knowledge of the installation of solar photovoltaic system
- Learn about the maintenance of solar photovoltaic system

Module I –Introduction
Introduction to solar photovoltaic system, Solar panels, solar photovoltaic energy conversion.

Module II –Solar Inverters:
Solar inverter, Types of solar inverters, Racking.

Module III – Solar PV System Installation
Assessment of site, Installation process – Scaffolding, solar panel mounts, installation of panels, wiring, installation of solar inverters, solar batteries bonding, connections and testing.

Module IV– Maintenance
Parameters for maintenance, cleaning and regular system check-ups.

References/Books:

- Solar PV System: Design, Installation, Operation and Maintenance – L. Ashok Kumar
- Solar Panel Installation Technician – AISCET Publications
- Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers – Chetan Singh Solanki

(SST.403) Engineering Graphics and Drawing

Course Outcomes – After the completion of this course, students will be able to:

- Get familiar with basic principles of engineering drawing.
- Learn about different types of lines used in engineering drawing.
- Learn about different types of scales used in engineering drawing.
- Draw projection of lines.
- Learn about AutoCAD

Module I: Introduction to Engineering Drawing

Principles of engineering drawing and their significance, usage of drawing instruments, sizes and layout of standard drawing sheets, size of drawing boards, drafting table/board.

Module II: Types of Lines & projection of lines

Different types of lines in engineering drawing as per BIS specifications, lettering, Projection of lines: Projections of points & lines inclined to both planes.

Module III: Scales

Plain, Diagonal and Vernier scales used in engineering drawing.

Module IV: Introduction to AutoCAD

Introduction of AutoCAD, Draw commands, modify commands.

References/Books:

- Surjit Singh, "Engineering Drawing: A Text Book of Engineering Drawing", Dhanpat Rai & Co.
- ND Bhatt, V.M Panchal, "Engineering Drawing – Planes & Solid Geometry", Charotar publishing house.
- Principles of Building Drawing by MG Shah and CM Kale, MacMillan, Delhi.
- Zaidi, SKA and Siddiqui, Suhail : " Drawing and Design of Residential and Commercial Buildings" , Standard Publishers and Distributors, Delhi.

(SST.404) SOLAR PHOTOVOLTAIC SYSTEM DESIGN AND INTEGRATION

Course outcomes –

After completing this course, students will be able to:

- Demonstrate knowledge of different solar cells modules and uses
- Describe working of the solar cell modules
- Explain the selection of batteries for different solar systems
- Design grid connected and standalone solar systems

Module I – Basics of Solar Photovoltaic Modules

Solar PV Electricity, Introduction of Solar PV Modules, Interconnections of PV Modules, Impact of environmental parameters on module performance.

Module II – Solar PV System Batteries

Introduction to Battery technologies, Battery losses and parameters, factors affecting batteries.

Module III – Converter and Controller Circuits

Types of DC-DC converters, DC-AC converters (inverters), Charge controllers, Maximum Power point Tracking.

Module IV – PV System Design and Integration

Design methodology and configurations of PV systems.

References/Books:

- Solar photovoltaics; Fundamentals, Technologies and Applications -- C. S. Solanki.
- Solar Electricity, 2nd edition, Wiley, 2000 -- Markvart T.
- Solar electricity; Engineering of photovoltaic systems -- E. Lorenzo.

(SST.405) Solar Technology Lab

Course Outcomes- At the end of this course, students will demonstrate the ability to-

- Understand the basics of solar photovoltaic modules.
- Understand the details of solar system batteries.
- Understand the details of converters controller circuits used in solar systems.
- Understand the concepts of PV system design and integration.

List of Experiments

1. To plot the current-voltage relationship & PV curve for the solar cell.
2. To measure the I-V characteristics of solar panel, when changes in tilt and seasonal angle occurs, using solar PV tracking system.
3. To study the various charge controlling techniques in order to protect the batteries from over charge and deep discharge.
4. To study DC-DC converter system.
5. To study DC-AC converter system.
6. To study different PV module technologies and their performance.
7. To measure the minority carrier lifetime of a solar cell.
8. To study the grid-connected solar PV system.
9. To study various types of batteries.
10. To study various parameters and losses in batteries.

(SST.406) Electrical Technology Lab

Course Outcomes- At the end of this course, students will demonstrate the ability to-

- Understand the use and importance of various types of equipment used in the laboratory.
- Understand the working of Wheatstone bridge.
- Understand the use of LCR meter, megger, digital multi-meter.
- Understand the use of potentiometer, CRO,Q-meter and flux-meter.

Lectures/Demonstrations

1. Colour coding of carbon resistance.
2. Construction and working of Wheatstone bridge.
3. Construction and working of LCR meter, digital multi-meter.
4. Construction and working of Megger, potentiometer, CRO, Q-meter & flux-meter.

List of Experiments

1. To determine the resistance of colour-coded resistance.
2. Measurement of L using LCR meter.
3. Measurement of C using LCR meter.
4. Measurement of unknown resistance using Wheatstone bridge.
5. Measurement of high resistance and insulation resistance using Megger.
6. To demonstrate the use of potentiometer.
7. To demonstrate the use of digital multimeter.
8. To demonstrate the use of CRO.
9. To study the operation of Q-meter.
10. To study the working of LUX meter.