B Voc
PROGRAMME

in

RENEWABLE ENERGY TECHNOLOGY

Syllabus (OLD)

FACULTY OF SCIENCE
UNIVERSITY OF LUCKNOW
LUCKNOW

10. STRUCTURE OF B Voc (RENEWABLE ENERGY TECHNOLOGY) PROGRAMME:

Module Code	Name	Credit	Marks
YEAR – 1, SEMESTER - I			
GENERAL EDUCATION			
Module RET - 101	Applied Mathematics I	3	100
Module RET - 102	Applied Chemistry	3	100
Module RET - 103	Biochemistry	3	100
Module RET - 104	Communication Skills I	3	100
SKILL COMPONENT			
Module RET – 105	Energy Sources and Energy Scenario	3	100
Module RET – 106	Energy, Ecology and Environment Studies	3	100
Module RET – 107	Bio-energy Conversion Systems	3	100
Module RET – 108	Waste to Energy Conversion Systems	3	100
Module RET – 109	Module RET – 109 Laboratory I	6	200
YEAR – 1, SEMESTER - II			
GENERAL EDUCATION			
Module RET – 201	Applied Physics-I	3	100
Module RET – 202	Basic Mechanical Engineering Systems	3	100
Module RET – 203	Thermodynamics, Heat and Mass Transfer	3	100
Module RET – 204	Communication Skills-II	3	100
SKILL COMPONENT			
Module RET – 205	Solar Thermal Engineering and Applications	3	100
Module RET – 206	Concentrating Solar Thermal Power Plants	3	100
Module RET – 207	Power Plant Engineering	3	100
Module RET – 208	Engineering Graphics and Drawing-I	3	100
Module RET – 209	Laboratory-II	6	200
	TOTAL	**60**	**2000**

YEAR – 2, SEMESTER - III			
GENERAL EDUCATION			
Module RET – 301	Applied Physics II	3	100
Module RET – 302	Material Science for Energy Applications	3	100
Module RET – 303	Electronics and Instrumentation	3	100
Module RET – 304	Communication Skills III	3	100
SKILL COMPONENT			
Module RET – 305	Solar Cell and Photovoltaic Technologies	3	100
Module RET – 306	Programming C++/Java	3	100
Module RET – 307	Engineering Graphics and Drawing II	3	100
Module RET – 308	Energy Storage Systems	3	100
Module RET – 309	Laboratory III	6	200
YEAR – 2, SEMESTER - IV			
GENERAL EDUCATION			
Module RET – 401	Data Analyses and Interpretation	3	100
Module RET – 402	Applied Mathematics II	3	100
Module RET – 403	Basic Electrical Engineering Systems	3	100
Module RET – 404	Project Writing I	3	100
SKILL COMPONENT			
Module RET – 405	MATLAB	3	100
Module RET – 406	Solar Photovoltaic Power Plants	3	100
Module RET – 407	Smart and Micro-grid	3	100
Module RET – 408	Wind Energy Conversion Systems	3	100
Module RET – 409	Workshop Practices I	6	200
	TOTAL	**60**	**2000**

YEAR – 3, SEMESTER - V			
GENERAL EDUCATION			
Module RET – 501	Project Writing II	3	100
SKILL COMPONENT			
Module RET – 502	Energy in Buildings	3	100
Module RET – 503	Mini and Micro Hydro Energy Systems	3	100
Module RET – 504	Other Renewable Energy Sources	3	100
Module RET – 505	Hydrogen Energy and Fuel Cells	3	100
Module RET – 506	Energy Modelling and Project Management	3	100
Module RET – 507	Energy Economics and Planning	3	100
Module RET – 508	Energy Conservation and Management	3	100
Module RET – 509	Workshop Practices II	6	200
YEAR – 3, SEMESTER - VI			
SKILL COMPONENT			
Module RET – 601	Industrial Training	10	350
Module RET – 602	Major Project	20	650
	TOTAL	**60**	**2000**

CURRICULUM STRUCTURE OF
B Voc (RENEWABLE ENERGY TECHNOLOGY) PROGRAMME

The structure and the syllabus of the Course will consist of:

YEAR – 1									
SEMESTER – I									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
Module RET - 101 Applied Mathematics I	2	1	0	3	Module RET – 105 Energy Sources and Energy Scenario	2	1	0	3
Module RET – 102 Applied Chemistry	2	1	0	3	Module RET – 106 Energy, Ecology and Environment Studies	1	1	1	3
Module RET - 103 Biochemistry	2	1	0	3	Module RET – 107 Bio-energy Conversion Systems	2	1	0	3
Module RET - 104 Communication Skills I	1	1	1	3	Module RET – 108 Waste to Energy Conversion Systems	2	1	0	3
-					Module RET – 109 Laboratory I	0	0	12	6
Total Credits – 30									
SEMESTER – II									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
Module RET – 201 Applied Physics I	2	1	0	3	Module RET – 205 Solar Thermal Engineering and Applications	2	1	0	3
Module RET – 202 Basic Mechanical Engineering Systems	2	1	0	3	Module RET – 206 Concentrating Solar Thermal Power Plants	2	1	0	3
Module RET – 203 Thermodynamics, Heat and Mass Transfer	2	1	0	3	Module RET – 207 Power Plant Engineering	2	1	0	3
Module RET – 204 Communication Skills II	1	1	1	3	Module RET – 208 Engineering Graphics and Drawing I	1	1	1	3
-					Module RET – 209 Laboratory II	0	0	12	6
Total Credits - 30									

YEAR - 2									
SEMESTER – III									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
Module RET – 301 Applied Physics II	2	1	0	3	Module RET – 305 Solar Cell and Photovoltaic Technologies	2	1	0	3
Module RET – 302 Material Science for Energy Applications	2	1	0	3	Module RET – 306 Programming C++/Java	1	1	1	3
Module RET – 303 Electronics and Instrumentation	2	1	0	3	Module RET – 307 Engineering Graphics and Drawing II	1	1	1	3
Module RET – 304 Communication Skills III	1	1	1	3	Module RET – 308 Energy Storage Systems	2	1	0	3
-					Module RET – 309 Laboratory III	0	0	12	6
Total Credits - 30									
SEMESTER – IV									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
Module RET – 401 Data Analyses and Interpretation	1	1	1	3	Module RET – 405 MATLAB	1	1	1	3
Module RET – 402 Applied Mathematics II	2	1	0	3	Module RET – 406 Solar Photovoltaic Power Plants	2	1	0	3
Module RET – 403 Basic Electrical Engineering Systems	2	1	0	3	Module RET – 407 Smart and Micro-grid	2	1	0	3
Module RET – 404 Project Writing I	1	1	1	3	Module RET – 408 Wind Energy Conversion Systems	2	1	0	3
-					Module RET – 409 Workshop Practices I	0	0	12	6
Total Credits - 30									

YEAR – 3									
SEMESTER – V									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
Module RET – 501 Project Writing II	1	1	1	3	Module RET – 502 Energy in Buildings	2	1	0	3
					Module RET – 503 Mini and Micro Hydro Energy Systems	2	1	0	3
					Module RET – 504 Other Renewable Energy Sources	2	1	0	3
					Module RET – 505 Hydrogen Energy and Fuel Cells	2	1	0	3
					Module RET – 506 Energy Modelling and Project Management	2	1	0	3
					Module RET – 507 Energy Economics and Planning	2	1	0	3
					Module RET – 508 Energy Conservation and Management	2	1	0	3
					Module RET – 509 Workshop Practices II	0	0	12	6
Total Credits - 30									
SEMESTER – VI									
GENERAL EDUCATION	**CREDIT**				**SKILL COMPONENT**	**CREDIT**			
	L	**T**	**P**	**C**		**L**	**T**	**P**	**C**
-	-	-	-	-	Module RET – 601 Industrial Training	0	0	20	10
-	-	-	-	-	Module RET – 602 Major Project	0	0	40	20
Total Credits - 30									

***L –** Lecture, ***T –** Tutorial, ***P –** Practical, ***C –** Credit

- After successful completion of Ist Semester, student will be **awarded Certificate in Renewable Energy Technology (Bio-energy Systems).**
- After successful completion of IInd Semester, student will be awarded **Diploma in Renewable Energy Technology (Bio-energy Systems and Solar Thermal Systems).**
- After successful completion of IVth Semester, student will be **awarded Advanced Diploma in Renewable Energy Technology (Bio-energy Systems and Solar Thermal and Photovoltaic Systems)**
- After successful completion of VIth Semester, student will be awarded **B Voc Degree in Renewable Energy Technology.**

SYLLABUS
OF
B Voc
RENEWABLE ENERGY TECHNOLOGY

Semester I
Module RET - 101
Applied Mathematics I

Unit I

An overview of differential calculus of functions of single and double variables, higher order derivatives of product of two functions of single variable Leibnitz Theorem, Differentiation of functions two variables, homogeneous functions and Euler's Theorem, change of variables Jacobean, total derivatives, approximation errors, extrema of functions of two variables, Simple applications.

Unit II

An overview of integral calculus of functions of one variable and several variables, double and triple integrals, change of order of integration, change of variables, applications of integration to find length of curves, surface area and volume, beta and gamma functions, some properties and applications.

Unit III

Point functions and vector functions, gradient divergence and curl, solenoidal vector, directional derivatives line, surface and volume integrals, theorems of green, Gauss Divergence Theorem, Stoke's Theorem (without proof)

Unit IV

Definitions of various types of matrices, rank of a matrix, adjoint of a matrix, elementary transformations, inverse of a matrix, system of linear non homogeneous equations, consistency and solutions, characteristic equations, eigen value and eigen vectors, Cayley Hamilton Theorem (without proof)

Text Books:

1. Grewal, B S Higher Engineering Mathematics, Khanna Publishers.
2. E. Kreyszig, Advanced Engineering Mathematics, Volume-I, John Wiley and Sons.
3. B. V. Ramana, Higher Engineering Mathematics, Tata Mc Graw-Hill Publishing Company Ltd.
4. R.K.Jain and S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publishing House.

Semester I
Module RET - 102
Applied Chemistry

Unit I

Properties of water. Hardness of water, Disadvantages of hard water, Techniques of water softening, Calgon, Zeolite, Water treatment method for boiler feed by internal process.

Phase rule and its applications to one component system (water and sulphur), Chromatographic methods, Distillation: principles, types and uses, solvent extraction method.

Unit II

Introduction to basic chemical thermodynamics, Enthalpy, Entropy, Concept of internal energy, Spontaneous reactions and criteria for spontaneity, Chemical reaction kinetics, Reaction mechanisms, Rate laws, Order of reactions.

Unit III

Photochemistry, Difference between thermal and photochemical reaction, absorption of radiation, absorption spectrum, Laws of photochemistry, Elementary ideas and simple applications of UV-Visible, IR, NMR spectroscopic techniques and their applications.

Unit IV

Polymers: classification and their applications, Thermoplastics, Thermosetting resins, Elastomers and Synthetic fibres, Conducting and biodegradable polymers, General methods of synthesis of organometallic compounds and their applications in polymerization and catalysis, Nanomaterials in bioenergy, possible hazards and health effects, liquid crystals and their applications, structure of fullerenes and their applications.

Text Books:

1. S. Vairam and Suba Ramesh, Chemistry for Engineers,Wiley India.
2. Gopal Krishna Bhatt, Textbook of Engineering Chemistry, Acme Publishers.
3. Raymond Chang, Chemistry (9th Ed), Tata McGraw-Hill.
4. Steven S. Zumdahl, Chemistry- Concepts and Applications, Cengage Learning.
5. Abhijit Mallick, Engineering Chemistry, Viva Books.
6. Harsh Malhotra, Text Book of Engineering Chemistry, Sonali Publications.
7. J.D. Lee, Concise Inorganic Chemistry, Wiley India.
8. Morrison and Boyd, Organic Chemistry (6 Ed), Pearson Education.
9. Gordon M. Barrow, Physical Chemistry, Mc-Graw Hill.
10. I. L. Finar, Organic Chemistry, Volume 1(6 Ed) & 2 (5Ed), Pearson Education.
11. Peter Atkins & Julio De Paula, Atkins' Physical Chemistry, Oxford University Press.

Semester I
Module RET - 103
Biochemistry

Unit I

Biochemical properties of prokaryotic and eukaryotic cell, Water and its importance to living systems, pH and biological buffers, Structure and function of bio-molecules: Proteins, carbohydrates and lipids, Metabolism of proteins, carbohydrates and lipids,

Unit II

Energy transduction in biological systems, photosynthetic efficiency, artificial photosynthesis, Biomass classification and properties, Bio-energy plantations, plant oils and their esters, Trans-esterification of vegetable oils into biodiesel. Microbial technology: Role of microbes in biofuel production and utilization, cyanobacterial hydrogen generation, microbial fuel cell, biorefining, Aerobic and Anaerobic enzymatic digestion of organic wastes into bio-gas and bio-methane.

Unit III

Enzymes: Nomenclature and classification, properties and factors affecting enzyme activity, enzyme kinetics, Isolation and purification of enzymes, specific activity, Application of enzyme technology in renewable energy industry: Enzymes in biomass feedstock pre-treatment and conversions into bio-energy, Enzyme technology for fuel production.

Unit IV

Structure and function of Nucleic acids, Recombinant DNA technology, Use of Transgenics in bioenergy production and utilization, Purification of bio-fuels using biochemical techniques: extraction methods, rotary evaporation, acid – base titration and chromatography.

Text Books:

1. David L. Nelson and Michael M. Cox Lehninger's Principles of Biochemistry, Macmillan Worth Publisher.
2. by Jeremy M Berg, Lubert Stryer, John L, Biochemistry 6th Edition, Tymoczko.
3. Murray, R.K., Granner, B.K., Mayes, P.A., Rodwell, V.W., Harper's Biochemistry, Prentice Hall International.
4. D. Voet and J. Voet, Voet and Voet's Biochemistry, 3rd Edition, John Wiley and Sons Inc.
5. by Eric E Conn, Paul K Stumpf, George Bruening and Roy H Doi, Biochemistry, 5th Ed.

Semester I
Module RET - 104
Communication Skills I

Unit I

Word Formation: Prefixes, Bases and Suffixes (Derivational & Inflectional), Synonyms and Antonyms; Homophones; Select vocabulary of about 500-1000 New words; Correct Usage: all Parts of Speech; Modals; Concord; Articles; Infinitives; Requisites of Sentence Construction: Paragraph Development: Techniques and Methods- Inductive, Deductive, Spatial, Linear, Chronological etc; The Art of Condensation-various steps.

Unit II

Communication: Meaning, Nature, Importance and Purpose of Communication, Types of Communication, Process of Communication, Communication Network in an Organization, Strategy for Effective Communication, Verbal and Non-Verbal Communication, Barriers to Communication, Essentials of Good Communication, Communication Techniques. The Process of Listening, Barriers to Listening, Types of Listening, Benefits of Effective Listening.

Unit III

Spoken English in India, The Organs of Speech, Description and Articulation of English Speech Sounds, Syllables and Stress (Weak Forms, Intonation), Connected Speech, Spelling and Pronunciation, International Phonetic Alphabet Transcription of Received Pronunciation of Words as per the Oxford Advanced Learners Dictionary of H.S. Hornby.

Unit IV

Presentation Skills, Interviews, Public Speaking, Preparing the Speech, Organizing the Speech, Special Occasion Speeches.

Classroom Practice:

- Greeting and introducing.
- Practicing Short Dialogues.
- Group Discussions, Seminars/Paper-Presentations.
- Listening News/Conversations/Telephonic Conversation.

Text Books:

1. Sethi, J, et al, A Practice Course in English Pronunciation, Prentice Hall of India, New Delhi.
2. Sen, Leena, Communication Skills, Prentice Hall of India, New Delhi.
3. Prasad, P., Communication Skills, S.K. Kataria and Sons.
4. Bansal, R.K. and J.B. Harrison, Spoken English, Orient Language.
6. A.S. Hornby's, Oxford Advanced Learners Dictionary of Current English, 7th Edition.

B Voc Renewable Energy Technology Semester I
Centre of Excellence in Renewable Energy Education and Research
University of Lucknow

Module RET - 105
Energy Sources and Energy Scenario

Unit I
Introduction to Energy
Definition and units of energy and power, Quality and concentration of energy sources, Conversion, calorific value, Forms of energy, Classification of energy sources, Conservation of energy, Energy flow diagram to the earth. Origin of fossil fuels, Time scale of fossil fuels, Role of energy in economic development and social transformation, Energy security.

Unit II
Energy and Growing Economy
Commercial energy production, Final energy consumption, Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy conservation and its importance, Energy strategy for the future, Energy Conservation Act-2001 and its features.

Unit III
Global Energy Scene
Energy consumption in various sectors, projected energy consumption for the next century, exponential increase in energy consumption, energy resources, coal, oil, natural gas, nuclear power and hydroelectricity, impact of exponential rise in energy consumption on global economy, future energy options.

Unit IV
Indian Energy Scene
Commercial and non-commercial forms of energy, energy consumption pattern and its variation as a function of time, energy resources available in India, urban and rural energy consumption, nuclear energy- promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources, Socio-economical impacts, Rural development, Poverty alleviation, Employment; Security of supply and use, Environmental and ethical concerns, Economical aspects of renewable energy systems vs large hydro and thermal power projects.

Text Books:

1. Bani P. Banerjee, Energy and the Environment in India, Oxford University Press, New Delhi.
2. G. D. Rai, Non- conventional Sources of Energy, Khanna Publishers, Delhi.
3. Gopal kumar, Energy Independence Vision of a Hybrid, Unbound Future, Deep and Deep Publications Pvt. Ltd., New Delhi.
4. D. K. Asthana, Meera Asthana, Environment Problems and Solutions, S. Chand and Company Ltd., New Delhi.
5. Abdul Mubeen, M. Emran Khan, M. Muzaffarul Hasan, Energy and Environment, Anamaya Publishers, New Delhi.
6. Upender Pandel, M. P. Poonia, Energy Technologies for Sustainable Development, Prime Publishing, Ghaziabad (UP).

B Voc Renewable Energy Technology Semester I
Centre of Excellence in Renewable Energy Education and Research
University of Lucknow

Module RET - 106
Energy, Ecology and Environment Studies

Unit I
Ecological Principles and Energy Flow
Ecological principle of nature, Concept of ecosystems, Different types of ecosystems; ecosystem theories, Energy flow in the ecosystems; biodiversity

Unit II
Fossil Fuel and Development
Energy and development linkage, Coal - sources, formation, important properties and uses, Petroleum - sources, genesis, important properties and uses, Natural gas - sources, genesis, important properties and uses

Unit III
Environmental Concerns of Energy Extraction
Environmental effects of energy extraction, conversion and use, Sources of pollution; primary and secondary pollutants, Consequences of pollution growth; air, water, soil, thermal, noise pollution-cause and effect, Pollution control methods, Environmental laws on pollution control, biological damage due to environmental degradation, Pollution due to thermal power station and their control. Pollution due to nuclear power generation, radioactive waste and its disposal. Effect of hydroelectric power stations on ecology and environment. Effect of Hydroelectric power stations on ecology and environment.

Unit IV
Energy Use and Climate Change
Global warming, Depletion of ozone layer, Green house gas emission, impacts, mitigation, Causes of global, regional and local climate change, International treaties and convention on environmental mitigation, United Nations Frameworks Convention on climate change (UNFCC), Various convention and treaties at international level aiming at CO_2 mitigation

Text Books:

1. Ristinen RA. Kraushaar JJ., Energy and the Environment, 2nd Edition, John Willey and Sons.
2. Banerjee BP., Handbook of Energy and Environment in India, Oxford University Press, India.
3. MC Dass, Fundamentals of Ecology, Tata McGraw Hill.
4. Kaushik ND, Kaushik K., Energy, Ecology and Environment, Capital Publishing.
5. De AK, Environmental Chemistry, New Age International Publishers.

B Voc Renewable Energy Technology Semester I
Centre of Excellence in Renewable Energy Education and Research
University of Lucknow

Module RET - 107
Bioenergy Conversion Systems

Unit I
Introduction
Overview of biomass as energy source; Biomass availability in India, Production of biomass, Photosynthesis, Photosynthetic efficiency, Classification of biomass, Biomass as Fuel: Physicochemical characteristics of biomass as fuel, Thermal characteristics of biomass as fuel, Biomass conversion routes: thermo-chemical, bio-chemical and agro-chemical.

Unit II
Thermo-Chemical Conversion of Biomass
Combustion in excess oxygen and oxygen deficient atmosphere, Pyrolysis, Carbonization, Charcoal production, Different types of biomass gasifiers, Power generation from gasification, Biomass based power generation, Overview of energy plantation, Basis of plants' selection for energy plantation, Wasteland utilization through energy plantation.

Unit III
Biochemical Conversion of Biomass for Energy Production
Anaerobic digestion, biogas production mechanism, Types of digesters and sizing, installation, operation and maintenance of biogas plants, Biogas plants manure-utilization and manure values, Biogas utilization and storage, Biogas for motive power generation etc.,

Unit IV
Agro-chemical Conversion of Biomass for Energy Production
Agro-chemical conversion processes, Hydrolysis and hydrogenation, Synthesis of bio-fuel: Modern bio-fuel synthesis, Bio- refinery, Liquid bio-fuel : Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel utilization in engines, Alcohol production from biomass, types of materials of alcohol production and description of process and utilization.

Text Books:

1. Mukunda HS, Understanding Clean Energy and Fuels from Biomass, Wiley-India Pvt. Ltd.
2. Pandey A, Hand book of Plant based Biofuel, CRC Press, Taylor and Francis.
3. Mital KM, Biogas Systems, Principle and Applications, New Age International Ltd.
4. Rai GD, Nonconventional Energy Sources, Khanna Publication.
5. Ravindranath NH, Hall DO, Biomass, Energy and Environment, A Developing Country Perspective from India, Oxford University Press.
6. Mukherjee D, Chakrabarti S, Fundamentals of Renewable Energy Systems, New Age International Publishers.
7. Twidell John, Weir Tony, Renewable Energy Sources, Taylor and Francis, London.

B Voc Renewable Energy Technology Semester I
Centre of Excellence in Renewable Energy Education and Research
University of Lucknow

Module RET - 108
Waste to Energy Conversion Systems

Unit I
Introduction
Introduction to waste and waste processing, Definitions, sources, types and composition of various types of wastes; Characterization of Municipal Solid Waste (MSW) , Industrial waste and Biomedical Waste (BMW), Waste collection and transportation; Waste processing-size reduction, Separation; Waste management hierarchy, Waste minimization and recycling of MSW; Life Cycle Analysis (LCA), Material Recovery Facilities (MRF), Recycling processes of solid waste.

Unit II
Waste Treatment and Disposal
Aerobic composting, Incineration, different type of incineration; medical and pharmaceutical waste incinerations, Landfill classification, types, methods and sitting consideration, layout and preliminary design of landfills: composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases, Rules related to the handling, treatment and disposal of MSW and BMW in India.

Unit III
Waste to Energy Conversion Technologies
Sources of energy generation, incineration, gasification of waste using gasifiers, briquetting, utilization and advantages of briquetting. Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, land fill gas generation and utilization,

Unit IV
Environmental and Commercial Aspects of Waste to Energy
Present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages, Environmental and health impacts of incineration and other waste to energy conversion systems, case studies of commercial waste to energy plants, Strategies for reducing environmental impacts.

Text Books:

1. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, ISBN:9780470539675, John Wiley and Sons.
2. Velma I. Grover and Vaneeta Grover, Recovering Energy from Waste Various Aspects, ISBN 978-1-57808-200-1.
3. Shah, Kanti L., Basics of Solid and Hazardous Waste Management Technology, Prentice Hall.
4. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers.
5. Marc J. Rogoff, Waste-to-Energy, Elsiever.
6. Parker, Colin and Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London.
7. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House.
8. Bhide A. D., Sundaresan B. B., Solid Waste Management in Developing Countries, INSDOC, New Delhi.

Semester I
Module RET - 109
Laboratory I

Experiments from Physics, Chemistry, Electronics, Environmental Studies and Energy Studies will be setups in Laboratory I for B Voc (Renewable Energy Technology) Programme to be performed by the students during Year - 1, Semester – I.

Semester II
Module RET - 201
Applied Physics I

Unit I
Condensed Matter Physics
Crystal Structure - Crystalline Matter - Bravias Lattice - Crystal Systems - Crystal Planes - and Miller Indices - Lattice Constants - Reciprocal Lattice - Crystal Structures - sc, bcc, fcc and hcp - Bragg's Law - Experimental Methods of X-Ray diffraction - Powder method.

Unit –II
Quantum Mechanics:
Black body radiation, Planck's law, Photoelectric phenomena, Compton effect, Wave-particle duality, de-Broglie matter waves, Phase and Group velocities, Davisson-Germer experiment, Heisenberg uncertainty principle, its illustration and applications.

Unit III
Electronics
Semiconductors, Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, levels; Determination of Fermi energy level; unbiased diode, Forward bias and Reverse bias diodes, p-n junction: homo- and hetro-junctions, diode characteristics, Zener diode, Avalanche and Zener Breakdown.

Unit IV
Wave Optics
Coherence and Interference of light, Interference in thin films, Newton's rings and its applications to determine wavelength of light and refractive index of a liquid, Diffraction, Single, Fraunhofer diffraction at multiple slits, limiting cases – single and double slits, Comparison between interference and diffraction, Fresnels diffraction, Fresnel's diffraction at straight edge and narrow wire .

Text Books:

1. Beiser, Concepts of Modern Physics, Mc-Graw Hill.
2. Robert Resnick, Introduction to Special Relativity, Wielly.
3. A. Ghatak, Optics, Tata McGraw Hill Education Private Ltd. New Delhi.
4. Brijlal and Subramanian, Optics, S. Chand.
5. Neeraj Mehta, Applied Physics for Engineers, PHI Learning, New Delhi.

Semester II
Module RET - 202
Basic Mechanical Engineering Systems

Unit I
Boilers
Types of Boilers, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down, Introduction, mechanism of fluidized bed combustion, advantages, types of FBC boilers, operational features, retrofitting FBC system to conventional boilers.

Unit II
Heating Ventilation and Air Conditioning Systems (HVAC)
HVAC, Heating systems, Ventilation systems, Refrigeration and Air Conditioning systems, Vapor compressor refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems, Working principle, type and comparison with vapor compressor systems.

Unit III
Mechanical Engineering Systems-1
Sterling engines, Steam engine, Internal combustion systems and external combustion system, Definition, need, application, advantages, classification, saving potential of Co-generation and Tri-generation, Overview of different types of turbines.

Unit IV
Mechanical Engineering Systems-2
Strength of materials, mechanical properties of materials, mechanics of materials, Torque and Power: Basic theory, Shafts, Flywheels etc. Power Transmission: Concepts of Belts Drives, Gearing, Coupling etc. Bearing and Lubricants as energy saving measures, Electromechanical energy: electric to mechanical energy conversion, Electric Motors.

Text Books:

1. A.W.Culp, Principles of Energy Conversion, McGrawHill International.
2. M.H. Mawhinney, Industrial Furnaces (Vol I & II), John Wiley Publications.
3. F.H. Nortan, Refractories, John Wiley Publication.
4. Kenneth Shaw, Refractories and their Uses, Applied Science Publishers Ltd.
5. G.B. Rotherberg, Refractory Material, Noyes data Coorp. N.I.
6. John R. Hughes, The Storage and Handling of Petroleum Liquid, Charles Griffin and Co. Ltd.
7. Wilfred Francis, Fuels and Fuel Technology, Pergamon Press.
8. Charles H. Burkhadt, Domestic and Commercial Oil Burners, McGraw Hill Publication.
9. Oliver Lyle, The Efficient Use of Steam, HMSO London.
10. Carl D. Shields, Boilers – Types, Characteristics and Functions, Mcgraw Hill Book.
11. R.J. Dossat, Principles of Refrigeration, Wiley Estern Limited.
12. Bhatt, Vora Stoichiometry, Tata Mc.Graw Hill.

Semester II
Module RET - 203
Thermodynamics, Heat and Mass Transfer

Unit I

Thermodynamics I

Basic concepts, Zeroth law and temperature, Energy interaction, First law of thermodynamics, Flow processes, Second law of thermodynamics, Role of thermodynamics in Energy conversion, Combined First and Second Laws, Thermodynamic and Kinetic temperature.

Unit II

Thermodynamics II

Entropy and availability, Third Law of Thermodynamics, Sensible heat, Latent heat, Boiling and Condensation, Evaporative cooling, Refrigeration, Heat pump, Carnot engine, Rankine cycle.

Unit III

Heat and Mass Transfer

Conduction, General Equation of Heat Conduction: steady conduction and unsteady conduction; Convection; Equations for mass, momentum and energy conservations; Natural convection; forced convection; Effect of turbulence on convective heat transfer.

Unit IV

Radiative Energy

Radiation: Black body radiation; Interaction of radiation with medium; Emissive power, Absorptive power; Kirchhoff's law and gray surface approximation, wien's displacement law, solar spectrum high temperature measurement, Radiation exchange between black and diffuse gray surfaces in an enclosure.

Texts Books:

1. P.K.Nag, Engineering Thermodynamics, Tata Mc-Graw Hill, New Delhi.
2. H.B. Callen, Thermodynamics and an Introduction to Thermostatistics, John Wiley, Toronto.
3. Bejan, Advanced Engineering thermodynamics, John Wiley, Toronto.
4. S. P. Sukhatme, Heat Transfer, University Press.
5. F. P. Incropera and D. P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons.
6. P. S. Ghoshdastidar, Heat Transfer, Oxford.

Semester II
Module RET - 204
Communication Skills II (Written Communication)

Unit I
Reading Skills: Purpose, Process, Methodologies, and Strategy.

Unit II
Effective Writing Skills: Elements of Effective Writing, Main Forms of Written Communication: Agenda, Minutes, Notices, Writing of CV, Memo, Drafting an E-mail, Press Release. Correspondence: Personal, Official and Business.

Unit III
Idioms and Phrases, Words Often Confused, One Word Substitutes, Word Choice: Right Words, Appropriate Words.

Unit IV
Remedial Grammar and Usage, Important Aspects of English Grammar and Usage, Phrases and Clauses.

Classroom Practical:

1. Group Discussion: Practical based on Accurate and Current Grammatical Patterns.
2. Conversational Skills for Interviews under suitable Professional Communication Lab conditions with emphasis on Kinesics.
3. Communication Skills for Seminars/Conferences/Workshops with emphasis on Paralinguistics/ Kinesics.
4. Presentation Skills for Technical Paper/Project Reports/ Professional Reports based on proper Stress and Intonation Mechanics.
5. Official/Public Speaking based on suitable Rhythmic Patterns.
6. Theme- Presentation/ Key-Note Presentation based on correct argumentation methodologies.
7. Individual Speech Delivery/Conferences with skills to defend Interjections/Quizzes.
8. Argumentative Skills/Role Play Presentation with Stress and Intonation.
9. Comprehension Skills based on Reading and Listening Practical on a model Audio-Visual Usage.

Text Books:

1. Prasad, P., The Functional Aspects of Communication Skills, Delhi.
2. Sen, Leena, Communication Skills, Prentice Hall of India, New Delhi.
3. McCarthy, Michael, English Vocabulary in Use, Cambridge University Press.
4. Rajinder Pal and Prem Lata, English Grammar and Composition, Sultan Chand Publication.

Semester II
Module RET - 205
Solar Thermal Engineering and Applications

Unit I
Solar Radiation
Solar radiation outside the earth's atmosphere, Solar radiation at the earth's surface, Instuments for measuring solar radiation and sunshine, Solar radiation Data, Solar radiation geometry, Empirical equations for predicting the availability of solar radiation, Solar radiation on tilted surfaces.

Unit II
Radiative Properties and Characteristics of Materials
Reflection from ideal specular, ideal diffuse and real surfaces, Selective Surfaces: Ideal coating characteristics, types and applications; Anti-reflective coating: Preparation and characterization.

Unit III
Flat-plate Collectors
Flat-plate Collectors, Energy balance for Flat Plate Collectors; Performance analysis, Transmissivity of the cover system, Transmissivity-absorptivity product, Incident angle modifier, overall loss coefficient and heat transfer correlations, collector efficiency factor, collector heat removal factor, effect of various parameters on performance, Transient analysis, testing procedures, Thermal analysis; Evacuated tubular collectors.

Unit IV
Solar Thermal Energy Systems
Fundamentals, design and applications of Solar still, Solar cooker, Solar drier; Solar pond, Solar passive heating and cooling systems, Trombe wall.

Text Books:

1. Sukhatme S.P., Solar Energy: Principles of Thermal Collection and Storage, Tata Mc Graw-Hill.
2. Duffie J. A., Beckman W. A., Solar Engineering of Thermal Processes, Johnn Wiley.
3. Green, Martin, 3rd Generation Photovoltaic: Advance Solar Energy, Springer.
4. Goswami D. Y., Frank Kreith and Kreider J. F., Principles of Solar Engineering, Taylor and Francis, USA.
5. Garg H.P., Prakash S., Solar Energy: Fundamental and Application, Tata Mc Graw-Hill, New Delhi.

Semester II
Module RET - 206
Concentrating Solar Thermal Power Plants

Unit I

Concentrating Collector Designs

Introduction of concentrating collectors, Parameters characterizing solar concentrator, classification of solar concentrators, Thermodynamic limits to concentration, parabolic geometries, paraboloid geometries (dish), error in concentration, Solar concentrator mountings, Solar incident angle for different concentrator mountings, Performance analysis of cylindrical parabolic collector, Compound parabolic collector, tracking requirements of a compound parabolic, concentrating collector (CPC), Performance analysis of compound parabolic concentrating collector (CPC).

Unit II

Focusing Concentrators

Point focusing solar concentrator, Parabolic of revolution, Central power receiver systems, Analysis of a central receiver system, Layout, design and performance study of heliostats, Layout, design and performance study of Scheffler dishes, Solar furnaces.

Unit III

Receiver and Solar Thermal Power Plants

Volumetric receiver, Direct absorption receiver, Receiver loss calculations, Thermal storage for solar power plants, Experience on solar thermal power plants, Techno economic evaluation of solar thermal power plants, market considerations.

Unit IV

Industrial Process Heat

Solar energy for industrial process heat, Temperature requirements of industrial process heat, Consumption pattern of heat in different industries industrial processes and scope of using solar energy for such processes, Case studies.

Text Books:

1. Goswami D Y, Kreith Frank and Kreider J F, Principles of Solar Engineering, Taylor and Francis, USA.
2. Tiwari G.N, Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, New Delhi.
3. Duffie J. A. and W. A. Beckman, Solar Engineering of Thermal Processes, Johnn Wiley.
4. Garg H P.et al, Solar Thermal Energy Storage, D Reidel Publishing Co.
5. Alexiades, V and A.D. Solomon, Mathematical Modeling of Melting and Freezing Process, Hemisphere Publishing Corporation, Washington.
6. Narayan R., B. Viswanathan, Chemical and Electrochemical Energy System, Universities Press.
7. Ter-Gazarian A., Energy Storage for Power Systems, Peter Peregrinus Ltd. London.
8. Kilkis B. and S. Kakac, Energy Energy Storage Systems, KAP, London.
9. Norton, B, Solar Thermal Energy Technology, Springer-Verlag, U.K.
10. G D Rai, Non-Conventional Sources of Energy, Khanna Publishers, Delhi.

Semester II
Module RET - 207
Power Plant Engineering

Unit I

Introduction

Choice of power generation; Load and Load duration curves; Load factor; Diversity factor; Load deviation curve; Load management; Number and size of generating unit; Cost of electrical energy; Tariff-Power factor improvement.

Unit II

Thermal Power Stations

Types of thermal power plants; elements of thermal power plant: Boiler, superheater, economiser, condenser, combustion chamber, gas loops and turbines etc., Site selection of Steam power plant, Principles of Electric Power station. General lay out. Instrumentation and control.

Unit III

Gas Turbine and Diesel-electric Power Plants

Gas Turbine Power Plants: Types, Open and close cycle gas turbines; Components of the plant, Plant lay out, Combined cycle power plant, Diesel-electric Power Plant: Working principle, Elements of the plant, Starting and stopping; Efficiency and Heat balance; Plant layout.

Unit IV

Nuclear Power Plants

Basic principles, Elements of Nuclear power plant, Nuclear reactor and fuels, Hazards due to Nuclear power plants, Nuclear Instrumentation.

Text Books:

1. P.K.Nag, Power Plant Engineering, Tata McGraw Hill.
2. Arora and Domkundwar, Power Plant Engineering, Dhanpat Rai and Co.
3. J.H.Horlock, Combined Power Plants, Pergamon Press.
4. Black , Veatch, Power Plant Engineering, CBS Published and Distributors.
5. Sh. H. Cohen, G. F. C. Rogers. H. I. H. Saravanamuttoo, Gas Turbine Theory, Longman Scientific and Technical.

Semester II
Module RET - 208
Engineering Graphics and Drawing I

Unit I

Drawing Practice

Importance of engineering drawing - drawing instruments: drawing board, mini drafter, compass, divider, protractor, drawing sheets etc., - layout of drawing sheets, Importance of legible lettering and numbering - single stroke letters - upper case and lower case letters- general procedures for lettering and numbering - height of letters – guidelines, Dimensioning - Need for dimensioning - terms and notations as per BIS - Dimension line, Extension line and Leader line - Methods of dimensioning – Importance of dimensioning rules – Exercises, Scales - Study of scales - full size scale, reduced scale and enlarged scale.

Unit II

Constructions of Conics

Conics: Different types – Definition of locus, focus and directrix - Applications of ellipse, parabola and hyperbola, Ellipse: Construction of ellipse by concentric circle method, rectangular method and Eccentricity method when focus and directrix are given – Practical applications, Parabola: Construction of parabola by rectangular method, parallelogram method and eccentricity method when focus and directrix are given– Practical applications, Hyperbola: Construction of hyperbola by rectangular method and eccentricity method when focus and directrix are given– Practical applications.

Unit III

Constructions of Special Curves

Geometric curves: Definition, application and construction of cycloid - epicycloid – hypocycloid – exercises, Involute of a circle - Archimedean spiral – helix – exercises**.**

Projection of Points

Projection of points – points in different quadrants, Projection of straight lines, Projection of straight lines – parallel to one plane and perpendicular to other plane – inclined to one plane and parallel to the other plane – parallel to both the planes – inclined to both the planes (simple problems only).

Unit IV

Orthographic Projection

Introduction – projection terms - Orthographic projection - Co-ordinate planes of projection - Systems of orthographic projection - First angle orthographic projection- Third angle orthographic projection - Comparison of first and third angle projections, Projection of three views (Elevation, Plan, Side view) of simple objects using first angle projection only – exercises, AutoCAD.

Text Books:

1. Gill P.S., Engineering Drawing, S.K.Kataria and Sons.
2. Bhat N.D., Engineering Drawing, Charotar Publishing House.
3. Gopalakrishnan.K.R., Engineering Drawing, (Vol.I and Vol.II), Dhanalakshmi Publishers.
4. Venugopal.K, Sreekanjana G, Engineering Graphics, New Age International Publishers.
5. Thomas E.French, Charles J.Vierck, Robert J.Foster, Engineering Drawing and Graphic Technology, McGraw Hill International Editions.
6. Barkinson and Sinha, First Year Engineering Drawing, Pitman Publishers.
7. Shah, Rana, Engineering Drawing, Pearson Longman.

Semester II
Module RET - 209
Laboratory II

Experiments from Environmental Studies, Energy Studies, Solar Thermal Energy Conversion and Solar Photovoltaic Energy Conversion will be setups in Laboratory II for B Voc (Renewable Energy Technology) Programme to be performed by the students during Year - 1, Semester – II.

Semester III
Module RET - 301
Applied Physics II

Unit I
Semiconductor Physics
Semiconductor, Bonds in Semiconductor, Energy Band Structure of semiconductors, Effect of Temperature On semiconductor, Concept of a hole, hole current, Effective mass of the electron in a crystal, Density of states in energy bands, Electron and hole concentration, Calculation of the Fermi Level, Theory of Electrical Conduction; Drift current, Mobility, Diffusion current, Generation of Carriers, Excess carrier lifetime, Minority carrier lifetime, Recombination of Carriers, Transport Equation.

Unit II
Optoelectronics
Optical radiation and light, Luminescence and Radiation, Radiation source parameters, Receiver parameters, Photometric and Radiometric terms and units, Inverse square law, Photonics and light technology and applications, Solar cells- Absorption of photons, Electricity generation and spectral Response.

Unit III
Physics of Materials
Crystal structure, atomic bonding, atomic packing, crystal imperfection; Point defect, linear defect, electrical properties of materials: Electrical Conductivity, Electronic and Ionic Conduction, Conduction in Terms of band and atomic bonding models, Electron mobility, Electrical resistivity of metals. Thermal properties of materials: Heat capacity, Thermal conductivity; heat transport by phonons and electrons.

Unit IV
Advance Technology in physics
Superconductors, Temperature dependence of resistivity in superconducting materials, Effect of magnetic field (Meissner effect), Type I and Type II superconductors, Critical Temperatures for superconducting materials, High temperature superconductors and applications of superconductors.
Nano-Materials, Basic principle of nanoscience and technology, effect and applications.

Text Books:

1. Semiconductor Physics and Devices – Donald A Neamen, Tata McGraw-Hill
2. Optoelectronic Engineering S.N. Biswass, Dhanpat Rai Publications
3. A Text book of Optics- Brijlal, Subramoniam, S Chand & Co
4. V. Raghavan, Materials Science and Engineering, Prentice- Hall India.
5. Materials Science and Engineering By William D. Callister
6. Neeraj Mehta, Applied Physics for Engineers, PHI Learning, New Delhi.
7. Nanostructures And Nanomaterials Synthesis, Properties, And Applications, Guozhong Cao, Imperial College Press, 2004 Chapter 3 And 5.
8. A Text book of Applied Electronics, R.S. Sedha – S. Chand (2005)

Semester III
Module RET - 302
Material Science for Energy Applications

Unit 1
Fabrication Techniques for Materials
Fabrications: Gas-solid and liquid-solid reactions-their role in micro engineering. Various reactors and methods of fabrication methods, such as physical and chemical vapour deposition techniques, photolithography, electroless and electrochemical deposition, etching, and through mask plating and common models to describe these processes.

Unit 2
New Generation Materials
New generation materials and nano-engineering of their structures for sustainable energy economy, Methods of production and properties of Carbon nano-tubes (CNTs) and Multiwall carbon nanotubes (MWCNTs) and its utility in energy devices. Classification, methods of production, properties, fabrication methods of Polymers and Composites and its utility in making energy devices, polymer based light emitting diodes.

Unit 3
Glass
Contribution to high performance renewable energy production, storage, conversion and usage of glass, Solar grade glass; Transparency, emissivity and reflectivity and manufacturing of flat glass for PV.

Unit 4
Materials for Solar Thermal Power
Materials for Concentrated Solar Power (CSP), tube glass for Evacuated Tube Receiver (ETR) and Collector (ETC), Glass, metal, polymer and film as reflective materials, Absorptive coating and anti-reflective coating for receiver and collectors.

Text Books:

1. Francis de Winter, Solar Collectors, Energy Storage, and Materials (Solar Heat Technologies), MIT Press, USA.
2. David S. Ginley, David Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press.
3. David MacKay and Neil Greenham, Materials, Electronics, and Renewable Energy Part III Physics, Small Lecture Theatre, Cavendish Laboratory Lecturers.

Semester III
Module RET - 303
Electronics and Instrumentation

Unit I

Diodes and Transistors

Qualitative explanation of mechanism, characteristics and simple application of junction device: p-n junction diode, transistors, funnel diode, unijunction transistor. Field effect devices : JEET, MOSFET, Qualitative explanation of mechanism, characteristics and simple application of M.W. devices: Gunn diode, IMPATT diode, PIN diode. Metal semiconductor devices : Schottky diode.

Unit II

Optical Devices and Electronics Components

Qualitative explanation of mechanism characteristics and simple application of Photodetectors, p-n photodiode, LEDs, Colour codes for resistor and capacitor, Identification and testing of resistors, capacitors, diodes and transistors, Introduction of bread boarding, tools, printed circuit boards, its making and component mounting and soldering.

Unit III

Sensors and Transducers

Introduction to instrumentation and controls of energy systems, display instruments, Recorders. Transducers based on p-n junctions, resistance, capacitance, piezoelectricity, sensors, actuators and Transmitters such as pressure, temperature, velocity, speed, volume, torque and solar flux measuring devices, current, voltage and power factor, IC fabrication principles: Integration of resistance, capacitance, diode, BJT in a monolithic circuit basis processes.

Unit IV

Instrumentation

Gas analysers, power plants and industrial instrumentation and pollution monitoring devices. Signal conditioning of Inputs, Single channel and multichannel Data Acquisition System, Computer based DAS, D/A and A/D converters, Data loggers, Supervisory control. Data Transmission systems, Advantage and Disadvantage of Digital Transmission over Analog. Time division multiplexing, Pulse Modulation, Digital Modulation.

Text Books:

1. H S Kalsi, Electronic Instrumentation, The Mc Graw-Hill Companies, New Delhi.
2. Copper. W.D and Hlefrick.. A.D, Modern Electronic Instrumentation and Measurement Techique, Prentice Hall of India.
3. Sawhney A.K, A Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai and Company Private Limited.
4. Golding. E. W, and Widdis F.C, Electrical Measurements and Measuring Instruments, A.H.Wheeler and Company.
5. Renganathan. S, Transducer Engineering, Allied Publishers, Chennai.
6. Doebelin. E.A, Measurement Systems – Applications and Design, Tata McGraw Hill, New York.
7. Patranabis. D, Sensors and Transducers, Prentice Hall of India.
8. John. P, Bentley, Principles of Measurement Systems, Pearson Education.
9. Murthy.D.V.S, Transducers and Instrumentation, Prentice Hall of India.

Semester III
Module RET - 304
Communication Skills III (Technical and Business Communication)

Unit I

Technical Communication

Technical Communication features: Distinction between General and Technical communication; Language as a tool of communication; Levels of communication: Interpersonal, Organizational, Mass communications, The flow of Communication: Downward, Upward, Lateral of Horizontal (Peer group): Importance of technical communication; Barriers to Communication.

Unit III

Business Communication

Business Communication principles, Sales & Credit letters; Claim and Adjustment Letters; Job application and Resumes. Reports: Types; Significance; Structure, Style & Writing of Reports. Technical Proposal; Parts; Types; Writing of Proposal; Significance. Negotiation & Business Presentation skills.

Unit III

Assignments

The students will be required to submit practical assignments on:

Writing CV, Memo Writing, Letter Writing (Employment related correspondence, Correspondence with Govt./Authorities, Office Orders, Enquiries and Replies), Business Letters , Preparing Agenda for Meetings, Essay Writing, Press Release

Unit IV

Value-Based Text Readings

Following essays form the suggested text book with emphasis on Mechanics of writing.

a) Humanistic and Scientific Approaches to Human Activity by Moody E. Prior
b) The Language of Literature and Science by A. Huxley
c) Man and Nature by J.Bronowski
d) The Social Function of Literature by Ian Watt
e) Science and Survival by Barry Commoner
f) The Mother of the Sciences by A.J.Bahm
g) The Effect of Scientific Temper on Man by Bertrand Russell.

Text Books:

1. V.N.Arora and Laxmi Chandra, Improve Your Writing Ed., Oxford Univ. Press, New Delhi.
2. Madhu Rani and Seema Verma, Technical Communication: A Practical Approach, Acme Learning, New Delhi.
3. Meenakshi Raman and Sangeeta Sharma, Technical Communication- Principles and Practices Oxford Univ. Press, New Delhi.
4. Sangeeta Sharma et.al., Communication Skills for Engineers and Scientists, PHI Learning Pvt.Ltd, New Delhi.
5. R.C.Sharma and Krishna Mohan, Business Correspondence and Report Writing Tata McGraw Hill & Co.Ltd., New Delhi.
6. Norman Lewis, W.R.Goyal, Word Power Made Easy, Pub. and Distributors, Delhi.
7. Krishna Mohan, Mecra Bannerji, Developing Communication Skills, Macmillan India Ltd., Delhi.
8. L.U.B.Pandey, Manual of Practical Communication, A.I.T.B.S. Publications India Ltd.; Krishan Nagar, Delhi.

Semester III
Module RET - 305
Solar Cell and Photovoltaic Technologies

Unit I

Properties of Semiconductor

Intrinsic, extrinsic and compound semiconductor; Energy levels; Electrical conductivity; Determination of Fermi energy level; Probability of occupation of allowed states; Dynamics of energy density of allowed states; Density of electrons and holes; Carrier transport: Drift, diffusion, continuity equations; Absorption of light; Recombination process; Basic equations of semiconductor devices physics.

Unit II

Photovoltaic Principles

Solar Cell Physics: p-n junction: homo and heterojunctions, Metal-semiconductor interface; The Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; High efficiency cells, Types of Solar cells

Unit III

Solar Cell Fabrication Technology

Preparation of metallurgical, electronic and solar grade Silicon; Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method: Procedure of masking, photolithography and etching; Design of a complete silicon, GaAs, InP solar cell.

Unit IV

High efficiency Solar cells

High efficiency III-V, II-VI multi-junction solar cell; a-Si-H based solar cells; Quantum well solar cell, Thermo-photovoltaics, Tendum solar cells, Organic solar cells and use of nano materials in Photovoltaics,

Solar Photo Voltaic (PV) cells: Single and multi-crystalline silicon solar cells, amorphous silicon, thin film; Cd-Te CIGS, CZTS, nano-, micro-, poly-Si. Transparent conducting coating, Multi-junction, solar PV concentrator, flexible solar cells, Emerging PV; dye sensitized, other organic, and quantum dot cells. Nano-engineered materials.

Text Books:

1. Sukhatme S. P., Solar Energy : Principles of Thermal Collection and Storage, Tata McGraw-Hill.
2. Duffie J. A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley and Sons.
3. Green M. A., Third Generation Photovoltics: Advanced Solar Energy, Springer.
4. Tiwari, G.N., Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, New Delhi.
5. Goswami, D. Yogi, Frank Kreith, Kreider Jan F., Principles of Solar Engineering, Taylor and Francis, USA.

Semester III
Module RET - 306
Programming Language: C++/Java

Unit I

Introduction to C++

Need and significance of programming languages The evolution of programming languages Types of Programming Language – Machine Language, Assembly Language, Procedural Languages, Non Procedural Languages, Object oriented programming Languages, Assembler, Interpreter and Compiler What is a Computer Program? The process of programming, Programming tools: a) Algorithm, b) Flowcharts.

Introduction to C++, History of C++,character set Keywords and identifiers Data types Constants and Variables and Rules for constructing variables and constants Arithmetic operators. Logical operators. Assignment operators. Increment and decrement operators. Relational operators. Conditional Operator Bitwise operators. Special operators. (e.g. Size of operator) ,Input and Output

Unit II

Programming with C++

Planning a C++ Program Writing a C++ Program Entering the program into the computer Compiling and executing. programming Errors Diagnostic Logical Debugging Decision control statement if, if …. else Iterative statement: while, do … while, for loops. Case Control Statement - switch ….case …. default statement Definition and purpose of functions Declaration of function. Function call Parameter processing Scope of variables.

Unit III

Introduction to Java

C++ vs Java, Java and Internet and WWW, Java support systems, Java environment. Java program structure, Tokens, Statements, Java virtual machine, Constant & Variables, Data Types, Declaration of Variables, Scope of Variables, Symbolic Constants, Type Casting. Operators : Arithmetic, Relational, Logical Assignments, Increment and Decrement, Conditional, Bitwise, Special, Expressions & its evaluation. If statement, if…else… statement, Nesting of if…else… statements, else…if Ladder, Switch, ? operators, Loops – While, Do, For, Jumps in Loops, Labelled Loops.

Unit IV

Programming with Java

Defining a Class, Adding Variables and Methods, Creating Objects, Accessing Class Members, Constructors, Methods Overloading, Static Members, Nesting of Methods. Inheritance: Extending a Class, Overriding Methods, Final Variables and Methods, Final Classes, Finalize Methods, Abstract methods and Classes, Visibility Control. Arrays: One Dimensional & two Dimensional, strings, Vectors, wrapper Classes, Defining Interface Extending Interface, Implementing Interface, Accessing Interface Variable, System Packages, Using System Package, Adding a Class to a Package, Hiding Classes.

Text Books:

1. Deitel and Deitel, C – How to Program, Pearson Education Asia.
2. Gottfried Byron, Programming with C, Tata McGraw Hill.
3. Kanetkar Yeshwant, Understanding Pointers in C, BPB Publications.
4. Kanetkar Yeshwant, Writing TSRs through C, BPB Publications.
5. Cay Horstmann, Big Java, John Wiley and Sons.
6. Herbert Schildt, The Complete Reference Java J2SE, TMH Publishing Company Ltd, New Delhi.

Semester III
Module RET - 307
Engineering Graphics and Drawing II

Unit I

Development of Surfaces

Need for preparing development drawing with reference to sheet metal work – Development of cube, cylinder, prism and pyramids, frustum of pyramids and cones – Exercises in triangular, square, pentagon and hexagon prisms and pyramids, cylinder and cone, Development of T-pipe, elbow, ducts, tray, lamp shade and funnel.

Unit II

Projection of Solids

Introduction - important terms - classification of solids – triangular and hexagonal prisms and pyramids - solids of revolution – cylinder and cone, Projections of solids in simple positions – parallel to one plane and perpendicular to other plane - projections of solids with axis inclined to HP and parallel to VP - projections of solids Curriculum Development Center - DOTE 190 with axis inclined to VP and parallel to HP - Projections of solids with axis parallel to both planes - exercises.

Unit III

Section of Solids

Introduction - section planes - apparent section - true section - sectional view - need for sectional view - cutting plane - cutting plane line, Section plane perpendicular to VP and parallel to HP - section plane perpendicular to HP and parallel to VP - section plane perpendicular to VP and inclined to HP - section plane perpendicular to HP and inclined to VP – Section of solids in simple positions – parallel to one plane and perpendicular to other plane - axis parallel to both planes showing true shape of section – exercises.

Unit IV

Isometric Projections

Introduction – isometric view - isometric projection – difference between isometric view and isometric projection - isometric scale - methods of drawing an isometric view- box method, Angles in Isometric view - irregular curves in isometric drawing - circles in isometric method – four centre method for drawing an ellipse - arcs of circles in isometric – Draw the isometric view of the object from the given orthographic view – exercises, Autocad.

Text Books:

1. Gill P.S., Engineering Drawing, S.K.Kataria and Sons.
2. Bhat N.D., Engineering Drawing, Charotar Publishing House.
3. Gopalakrishnan.K.R., Engineering Drawing, (Vol.I and Vol.II), Dhanalakshmi Publishers.
4. Venugopal.K, Sreekanjana G, Engineering Graphics, New Age International Publishers.
5. Thomas E.French, Charles J.Vierck, Robert J.Foster, Engineering Drawing and Graphic Technology, McGraw Hill International Editions.
6. Barkinson and Sinha, First Year Engineering Drawing, Pitman Publishers.
7. Shah, Rana, Engineering Drawing, Pearson Longman.

Semester III
Module RET - 308
Energy Storage Systems

Unit I

Introduction

Need of energy storage; Different modes of Energy Storage. Energy Storage : Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors and electromagnets.

Unit II

Electrochemical Energy Storage

Battery storage systems such as Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Role of carbon nano-tubes in electrodes; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels, and hydrogen storage.

Unit III

Sensible Heat and Latent Heat Storage

Sensible Heat Storage (SHS) mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage, Latent Heat Thermal Energy Storage **:** Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process.

Unit IV

Magnetic and Electric Energy Storage Systems

Superconducting Magnet Energy Storage (SMES) systems ; Capacitor and Batteries: Comparison and application ; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

Text Books:

1. Wolf, Edmond L., Nanoparticles and Nanotechnology: An Introduction to Modern Concepts of Nanoscience, John Wiley and Sons, Canada.
2. Narayan R., Viswanathan B., Chemical and Electrochemical Energy Systems, University Press (India) Ltd.
3. Sarangpani, S. J. A. Kosek, LaConti A. B., Handbook of Solid State Batteries and Capacitors, World Scientific Publications, NJ, USA.
4. Newman, J., Electro-chemical Systems, Prentice Hall, Engelwood Cliffs, NJ, USA.
5. Gileadi, E., Electrode Kinetics for Chemists, Chemical Engineers and Material Scientist, VCH Publications, NY, USA.
6. Harris, Peter J. F., Carbon Nanotubes and Related Structures-New Materials for the Twenty-first Century, Cambridge University Press, UK.
7. Reich, Stefan, C. Thomsen, Maultzsch J., Carbon Nanotubes – Basic Concepts and Physical Properties, John Wiley and Sons, Canada.

Semester III
Module RET - 309
Laboratory III

Experiments from Solar Thermal Energy Conversion, Solar Photovoltaic Energy Conversion, Wind Energy and Biomass Systems will be setups in Laboratory – III for B Voc (Renewable Energy Technology) Programme to be performed by the students during Year - II, Semester – III.

Semester IV
Module RET - 401
Data Analysis and Interpretation

Unit I
Introduction
Data and Its Properties, Analytical Methods and Jargon, Types of Data, Sources of Data, Dependent Data, Independent Data, The Nature of Data, Types of Data and Scales of Measurement, Data Distribution, Deviations in Distribution

Unit II
Analytical Methods
Business Statistics and Data Processing, Data types, Data collection and analysis, Sampling , need, errors and methods of sampling, Normal distribution, Hypothesis testing, Analysis and Interpretation of Data. Correlation and Regression, small sample tests: t- test, F- test and chi-square test.

Unit III
Using Excel for Data Analysis
Data Processing: Elements, Data entry, Data processing and Computer applications. Using Excel for Data Analysis, Case studies.

Unit IV
SPSS-Statistical Package for the Social Sciences
SPSS-Statistical Package for the Social Sciences, data entry, analysis, tables and graphs, case studies.

Text Books:

1. Bhattacharyya, G.K. and Johnson, R.A., Statistical Concepts and Methods, John Wiley, New York.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B., Fundamentals of Statistics, Vol. I, World Press, Kolkata.
3. Hogg, R.V. and Tanis, E.A., Probability and Statistical Inference, Pearson Education, Delhi.
4. Mathur, Rajiv, Learning EXCEL-97 for Windows Step by Step, Galgotia, New Delhi.
5. Page, Clive, G., Professional Programmers Guide to FORTRAN – 77, Pitman Publishing House, London.
6. Cochran, W.G., Sampling Techniques, Wiley Eastern, New Delhi.
7. Mukhopadhyay, P., Theory and Methods of Survey Sampling, Prentice Hall of India, New Delhi.
8. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C., Sampling Theory of Surveys with Applications, Iowa State University Press and IARS.

Semester IV
Module RET - 402
Applied Mathematics II

Unit I

Ordinary linear differential equations with constant coefficients (both homogeneous and nonhomogeneous) some simple examples from physical and engineering sciences, Complementary function and Particular integral, second order linear differential equations with constant coefficients with applications in LCR circuits and mechanical vibrations.

Unit II

Laplace transform, definitions and properties, first and second shifting theorems, Laplace transform of periodic functions, convolution theorem, inverse Laplace transform, applications to the solution of initial value problems in ordinary linear differential equations with constant coefficients.

Unit III

Solution of polynomial and transcendental equations by secant and Newton-Raphson method, solution of the system of linear algebraic equations by Gaussian elimination method, Jacobi method, Gauss-Seidel method, Lagrange and Newton interpolatory polynomials, numerical integration by trapezoidal and Simpson 1/3 rule.

Unit IV

Mean, mode, median, deviations, standard deviation, moment, frequency distribution, skewness and kurtosis, curve fitting using least square method, correlation and regression, properties and applications, binominal, Poisson and normal distributions and their simple applications.

Text Books:

1. E. Kreyszig, Advanced Enginnering Mathematics, Volume-II, John Wiley and Sons.
2. B. V. Ramana, Higher Engineering Mathematics, Tata Mc Graw- Hill Publishing Company Ltd.
3. R.K. Jain and S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publishing House.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.

Semester IV
Module RET - 403
Basic Electrical Engineering Systems

Unit I

Basics of Electrical Engineering

Fundamentals of electricity, Concepts of different electrical parameters like voltage, current, frequency, D.C and A.C circuits, Electrical power and energy, Resistive, Inductive and Capacitive electrical loads, Phasor Notation, Power in A.C. Circuits, Single and Three Phase A.C. Power, Star and Delta connections, Voltage levels, Transformers, Generators, Alternators, etc.

Unit II

Electrical Energy Generation, Transmission and Distribution

Importance of electrical energy in modern industrial society, Production of electricity using coal, oil, natural gas, nuclear fuels and hydel, its relative advantages and disadvantages, Synchronization, Transmission and distribution of electricity, Transmission and Distribution losses, Pilferage, Transformer losses. Electricity tariff, Load management and maximum demand control, power factor improvement and its benefits, Selection and location of capacitors etc., Villages electrification program and problems in India.

Unit III

Electrical Utility Systems 1

Conversion of Electrical Energy to Mechanical Energy, Types of Electric Motors, Losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, Energy efficient motors, Types of fans and blowers, Performance evaluation, efficient system operation, flow control strategies of fans and blowers.

Unit IV

Electrical Utility Systems 2

Types, performance evaluation of pumps and pumping systems, Efficient system operation, flow control strategies, variable speed drives for pumps and pumping systems, Types and performance evaluation of cooling towers, Efficient system operations, flow control strategies, assessment of saving opportunities for cooling towers, Factors affecting selection, energy performance assessment of diesel generating systems.

Text Books:

1. C. L. Wadhwa, Electrical Power Systems, New Age International Publishers, New Delhi.
2. Rajiv Shankar, Energy Auditing in Electrical Utilities, Viva Books Private Limited, New Delhi.
3. Mohamed A EI-Sharkawi, Electric Energy: An Introduction, CRC Press, Taylor and Francis Group, London.
4. H Partab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai and Co. (P) Ltd, Educational and Technical Publishers, New Delhi.
5. C L Wadhwa, Generation Distribution and Utilization of Electrical Energy, New Age International Publishers, New Delhi.

Semester IV
Module RET - 404
Project Writing I (Business Writing)

Unit I

Introduction to Business Communication, Characteristics of Effective Organizational Communication, Basic Forms of Communication, Process of Communication, Principles of Effective Business Communication, 7 C's.

Unit II

Barriers to Communication, Facilitators to Communication, Effective Listening, Perception and Reality, Role of Opinion, Attitudes & Beliefs, , Mal-functions of communication, Business Etiquettes.

Unit III

Forms of Business Communication, Written Communication, Oral Communication, Non-verbal Communication, Technology of Business Communication, Peculiarities of Communication in Indian Organizations, Conflict Management.

Unit IV

Conduct of Meetings, Agenda, Notice, Notes, Minutes, Office Memorandum, Office Orders, Press Release, Business Letter Writing-need, functions and kinds, Layout of letter writing, Types of letter writing, Problems in report writing, Organization and techniques of writing.

Text Books:

1. Chicago Manual of Style,14th Ed., Prentice Hall of India.
2. Collins' Cobuild English Dictionary, Harper Collins.
3. Gordon HM and Walter JA, Technical Writing., Holt, Rinehart and Winston.
4. Hornby AS, Comp. Oxford Advanced Learner's Dictionary of Current English, Oxford University Press.
5. James HS, Handbook for Technical Writing, NTC Business Books.
6. PG Curricula and Syllabi of UAS, Dharwad (As amended up to June 2013)
7. Joseph G, MLA Handbook for Writers of Research Papers, Affiliated East-West Press.
8. Mohan K, Speaking English Effectively, MacMillan India.
9. Richard WS, Technical Writing, Barnes and Noble.
10. Robert C. (Ed.), Spoken English: Flourish Your Language, Abhishek.
11. Sethi J and Dhamija PV, Course in Phonetics and Spoken English, Prentice Hall of India.
12. Wren PC and Martin H., High School English Grammar and Composition, S. Chand and Co.

Semester IV
Module RET - 405
MATLAB

Unit I
Introduction to MATLAB
Matrix Algebra, Basic Matrix Operations. Introduction to Mathematical softwares. Using MATLAB, the MATLAB environment, Command Window, Toolbar, Matrix creation, Matrix manipulation

Unit II
MATLAB Progamming
Logical variables and operators, Flow control, Loop operators, Writing functions, Input/output arguments, Function visibility, path., Writing script files, M-files

Unit III
Graphics in MATLAB
Making Plots, Graphics-Line chart, bar chart, pie chart, 2D Plots, 3D Graphics, Graphics Formats, Printing and Saving Graphics.

Unit IV
Advance MATLAB
Simulation in MATLAB, Data and data flow in MATLAB, Data types, Matrix, string, cell and structure, Creating, accessing elements and manipulating of data of different types, File Input-Output, Matlab files, Text files, Binary files, Mixed text-binary files

Text Books:

1. Bansal R.K, Goel A.K, Sharma M.K, MATLAB and its Applications in Engineering, Pearson Education.
2. Amos Gilat, MATLAB-An Introduction with Applications, Wiley India.
3. Stephen J Chapman, Programming in MATLAB for Engineers, Cengage Learning.
4. Rao V. Dukkipati, Solving Vibration Analysis Problems Using MATLAB, New Age International Publishers.
5. Rao V. Dukkipati, Analysis and Design of Control Syatems using MATLAB, New Age International Publishers.

Semester IV
Module RET - 406
Solar Photovoltaic Power Plants

Unit I
Solar Photovoltaic System Design
Solar cell array system analysis and performance prediction; Shadow analysis: Reliability; Solar cell array design concepts; PV system design; Design process and optimization; Detailed array design; Storage autonomy; Voltage regulation; Maximum tracking; Use of computers in array design; Quick sizing method; Array protection and trouble shooting.

Unit II
Balance of System
Design of structures and installation, Power conditioning and control: converters, inverters, cabling: size, losses, etc., other components of balance of system, Storage batteries, Battery charge controllers.

Unit III
SPV Applications
Centralized and decentralized SPV systems; Stand alone, hybrid and grid connected systems, domestic lighting ; street lighting ; water pumping, Applications in Telecommunications, cathodic protection, navigational aids, remote aircraft beacons, alarm systems, automatic meteorological stations, defense equipment and emergency equipment; System installation, operation and maintenances; Field experience.

Unit IV
Solar Photovoltaic Power Plants
Planning, design, installation and monitoring with or without storage system of solar photovoltaic power plants, PV market analysis, economics of solar photovoltaic power plant, Case studies.

Text Books:

1. Sukhatme S. P., Solar Energy : Principles of Thermal Collection and Storage, Tata McGraw-Hill.
2. Duffie J. A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley and Sons.
3. Green M. A., Third Generation Photovoltics: Advanced Solar Energy, Springer.
4. Tiwari, G.N., Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, New Delhi.
5. Goswami, D. Yogi, Frank Kreith, Kreider Jan F., Principles of Solar Engineering, Taylor and Francis, USA.

Semester IV
Module RET - 407
Smart and Micro-grid

Unit I

Introduction to Smart Grid

Comparison between existing grid and smart grid, Objectives, benefits and challenges of smart grid, Basic structure and functions of components of smart grid, Active distribution networks, virtual power plants, other initiatives and demonstrations of early smart grid initiatives.

Unit II

Communication Technologies for the Smart Grid

Two-way Digital Communications Paradigm, Network architectures, IP-based systems, Power line communications and advanced metering infrastructure.

Unit III

Sensing, Measurement, Control and Automation Technologies

An overview of the hardware used, communications infrastructure and protocols for smart metering, Demand-side integration, Sub-station automation equipment, faults in the distribution system, voltage regulation of distribution automation equipment.

Unit IV

Distribution and Transmission Management Systems

Introduction, data sources and associated external systems of distribution management system, SCADA, Customer information system, Modeling and analysis tools, Distribution system modeling, Topology analysis, Load forecasting, Power flow analysis, Fault calculations, etc., Applications, Introducation to transmission system operation, Data sources, IEDs and SCADA, Phasor measurement units, Energy management systems, on-line transient stability controller, pole-slipping preventive controller and visualization techniques for wide area applications.

Text Books:

1. Janaka Ekanayake, Kithsiri Liyanage, Smart Grid Technology and Applications, Wiley A John Wiley and Sons, Ltd., New Delhi.
2. P. Sioshansi, Smart Grid: Integrating Renewable, Distributed & Efficient Energy, Elsevier Inc.
3. J.A. Momoh, Smart Grid: Fundamentals of Design and Analysis, IEEE, John Wiley and Sons, Inc.
4. Peter Fox-Penner, Smart Power: Climate Change, The Smart Grid, and the Future of Electric Utilities, Island Press.

Semester IV
Module RET - 408
Wind Energy Conversion Systems

Unit I

Wind Resource Assessment

Current status and future prospects, Wind Energy in India, Wind maps, Site evaluation and site selection, Power available in the wind, Wind Turbine power and torque characteristics, Classification of WECSs, Horizontal and Vertical axis wind turbine, Anemometers and wind directions.

Unit II

Aerodynamics of Wind Turbine

Rotor design and Performance analysis, Aerodynamic, Airfoil, lift and drag characteristics, Power coefficient and tip-speed ratio.

Unit III

Wind Energy Conversion Systems

Wind electric generators: Tower, rotor, gearbox, power regulation, safety mechanisms, Generator: Induction and synchronous generator, Grid integration, Wind pumps.

Unit IV

Wind Energy Systems: Environment and Economics

Environmental benefits and problems of wind energy, Economics of wind energy: Factors influencing the cost of energy generation, Life cycle cost analysis.

Text Books:

1. Johnson GL., Wind Energy Systems, Prentice Hall Inc.
2. Mathew S., Wind Energy: Fundamentals, Resource Analysis and Economics, Springer.
3. Burton T. Sharpe D. Jenkins N. Bossanyi E., Wind Energy Handbook. John Wiley.
4. Jha AR., Wind Turbine Technology, CRC Press, Taylor and Francis.
5. Jain P., Wind Energy Engineering, McGraw-Hill.

Semester IV
Module RET - 409
Workshop Practices I

Introduction to safety measures, introduction to the principles of working, construction, operation, types of cutting tools, selection of cutting speeds and feeds etc. regarding basic machine tools e.g. lathe, shaping, slotting, milling and grinding machines, etc. Introduction to gas and arc welding processes, soldering and brazing. Exercise; simple jobs on centre lathe and shaping machines and welding. emonstrations; Slotting, milling and grinding machines.

Carpentry Shop:

- Study of tools & operations and carpentry joints.
- Simple exercise using jack plane.
- To prepare half-lap corner joint, mortise & tennon joints.
- Simple exercise on woodworking lathe.

Fitting (Bench Working) Shop:

- Study of tools & operations
- Simple exercises involving fitting work.
- Make perfect male-female joint.
- Simple exercises involving drilling/tapping/dieing.

Text Book:

1. S. K. Hajra Choudhury, Elements of Workshop Technology, Vol. II Asia Publishing House.

Semester V
Module RET - 501
Project Writing II (Technical Writing)

Unit I
Various forms of scientific writings- theses, technical papers, reviews, manuals, etc;

Unit II
Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);

Unit III
Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups;

Unit IV
Editing and proofreading; Writing of a review article.

Text Books:

1. Chicago Manual of Style,14th Ed., Prentice Hall of India.
2. Collins' Cobuild English Dictionary, Harper Collins.
3. Gordon HM and Walter JA, Technical Writing., Holt, Rinehart and Winston.
4. Hornby AS, Comp. Oxford Advanced Learner's Dictionary of Current English, Oxford University Press.
5. James HS, Handbook for Technical Writing, NTC Business Books.
6. PG Curricula and Syllabi of UAS, Dharwad (As amended up to June 2013)
7. Joseph G, MLA Handbook for Writers of Research Papers, Affiliated East-West Press.
8. Mohan K, Speaking English Effectively, MacMillan India.
9. Richard WS, Technical Writing, Barnes and Noble.
10. Robert C. (Ed.), Spoken English: Flourish Your Language, Abhishek.
11. Sethi J and Dhamija PV, Course in Phonetics and Spoken English, Prentice Hall of India.
12. Wren PC and Martin H., High School English Grammar and Composition, S. Chand and Co.

Semester V
Module RET - 502
Energy in Buildings

Unit I

Thermal Analysis and Design for Human Comfort

Introduction to architecture; Architecture as the art of science of designing buildings ; Building science and its significance; Energy management concept in building, Thermal comfort; Criteria and various parameters; Psychometric chart; Thermal indices, Climate and comfort zones; Concept of sol-air temperature and its significance; Calculation of instantaneous heat gain through building envelope; Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air-conditioning systems.

Unit II

Passive Cooling and Heating Concepts

Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel.

Unit III

Heat Transmission in Buildings

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

Unit IV

Bioclimatic Classification and Energy Efficient Landscape Design

Bioclimatic classification of India; Passive concepts appropriate for the various climatic zones in India; Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes, Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Sitting and orientation.

Text Books:

1. Tiwari G.N., Goyal R.K., Greenhouse Technology: Fundamentals, Design Modeling and Application, Narosa Publishing House.
2. Krieder J., Rabi A., Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill.
3. Archie, Culp W., Principles of Energy Conservation, McGraw Hill.
4. P. O. Callaghan, Energy Management, McGraw - Hill Book Company.
5. J.R. Williams, Passive Solar Heating, Ann Arbar Science.
6. Jones,R.W. Balcomb J.D., Kosiewiez C.E., Lazarus G.S., McFarland R.D., Wray W.O., Passive Solar Design Handbook, Vol. 3, Report of U.S. Department of Energy (DOE/CS-0127/3).
7. Majumder Milli, Energy Efficient Buildings, TERI, New Delhi.
8. David A. Bainbridge, Ken Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows, Chelsea Green Publishing Co., UK.

Semester V
Module RET - 503
Mini and Micro Hydro Energy Systems

Unit I

Hydropower

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

Unit II

Basics of Fluid Mechanics

Classification of Fluids, Characteristic of Water, units of Pressure, Pascal's law, applications of Pascal's law, Hydraulic press, Pressure measurement, Types of fluid flow, stream line and turbulent flow, Velocity Equation, Bernoulli's Equation, Power Equation, Continuity Equation, Cavitations, venturi meter, orifice meter, Pitot tube.

Unit III

Components of Hydropower Plants

Components of hydropower plants, Hydraulic Turbines: Types and Operational Aspects: Classification of Hydraulic Turbines, Theory of Hydroturbines; Francis, Pelton, Kaplan and Propeller Turbine; differences between impulse and reaction turbines; Operational Aspects of Turbines, Efficiency and selection of turbines, Types of generators - synchronous and induction, transformers, protection & control, transmission and distribution system., Dam and Spillway, Surge Chambers, Penstock, Tailrace.

Unit IV

Hydropower plant development

Site selection, environmental aspect, run-of-the-river and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, penstock and power house; transmission and distribution system, Economics: cost structure, Initial and operation cost. Environmental issues related to small and large hydropower plants, Potential of hydro power in India.

Text Books:

1. Hussian Z. Abdullah MZ. Alimuddin Z., Basic Fluid Mechanics and Hydraulic Machines, CRC Press.
2. Jiandong T., Mini Hydropower, John Wiley.
3. Wagner H. Mathur J., Introduction to Hydro energy Systems : Basics, Technology and Operation, Springer.

Semester V
Module RET - 504
Other Renewable Energy Sources

Unit I

Ocean Thermal Energy Conversion (OTEC)

Introduction to OTEC, Methods of ocean thermal electric power generation, Bio-fouling, Site selection, Energy utilization, Prospects of ocean thermal energy conversion systems in India.

Unit II

Wave and Tidal Energy

Introduction to tides, Basic principles of tidal power, Components of tidal power plants, Operation methods of utilization of tidal energy, estimate of energy and power in simple single basin tidal systems and double cycles systems, site requirements, storage, advantages and limitation of tidal power generation and prospect of tidal energy in India, Introduction to ocean waves, advantages and disadvantages of wave energy, Energy and power from waves, Wave-energy conversation devices.

Unit III

Geo-thermal Energy

Estimate of Geothermal power, Nature of geothermal fields, Geothermal sources, Hydrothermal resources, Geo-pressurized resources, Hot dry rock resources, Magma resources, Comparison of flashed steam and total flow concept, Prime movers for geothermal energy conversation, Advantages and disadvantages of geothermal energy, Application of geothermal energy, Geothermal energy in India.

Unit IV

Nuclear and Magneto Hydro Dynamic Power (MHD)

Nuclear fission and fusion; Magneto-hydro-dynamic (MHD) power generation, MHD systems, Advantages of MHD systems, International status of MHD power generation and its future prospects.

Text Books:

1. Kruger P., Alternative Energy Resources: The Quest for Sustainable Energy, Wiley Publication.
2. Rosa Aldo V., Fundamentals of Renewable Energy Processes, Second Edition, Academic Press.
3. Boyle G., Renewable Energy: Power for a Sustainable Future, Second Edition, Oxford University Press.
4. Sorensen Bent, Renewable Energy, Academic Press, New York.
5. Johansson Thomas B., Renewable Energy: Sources for Fuels and Electricity, Earthscan Publishers, London.
6. G. D. Rai, Non Conventional Sources of Energy, Khanna Publishers, Delhi.

Semester V
Module RET - 505
Hydrogen Energy and Fuel Cells

Unit 1
Hydrogen Energy
Merit as a fuel, applications of Hydrogen, Hydrogen production methods, Production of Hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, Hybrid systems.

Unit 2
Hydrogen Storage Methods
Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes storage of Hydogen, Sea as the source of Deuterium.

Unit 3
Fuel Cell
Basics Fuel cell definition, difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant.

Unit 4
Types of Fuel Cells
Alkaline fuel cell, , polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, Geometries of solid oxide fuel cells: planar, tubular, Types of solid oxide fuel cells: High temperature, intermediate temperature, Single chamber solid oxide fuel cells, Problems with fuel cells, Applications of fuel cells. Description of some commercially available fuel cell stacks, Overview on research activities on fuel cells in world, Research and development related to fuel cell development in India.

Text Books:

1. O'Hayre R., Cha S., Colella W., Prinz F. B., Fuel Cell Fundamentals, John Wiley and Sons, New York.
2. Sorensen, B., Hydrogen and Fuel Cells, Elsevier Academic Press, USA.
3. Sarangpani, S. J. A. Kosek, LaConti A. B., Handbook of Solid State Batteries and Capacitors, World Scientific Publications, NJ, USA.
4. Yurum, Yuda, Hydrogen Energy Systems, NATO ASI Series, London.
5. Baker, B.S., Hydrocarbon Fuel Cell Technology, Academic Press, New York.
6. B Viswanathan, M Aulice Scibioh, Fuel Cells: Principles and Applications, Universities Press, Chennai.
7. Charles C Sorrell, Sunao Sugihara and Janusz Nowotny, Materials for Energy Conversion Devices, WP Woodhead Publishing, New Delhi.

Semester V
Module RET - 506
Energy Modeling and Project Management

Unit I

Introduction

Basic concept of econometrics and statistical analysis; The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies from India; Operation of computer package

Unit II

Input – Output Analysis

Basic concept of Input-output analysis; concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input - Output analyses using I-O model.

Unit III

Energy Modeling

Interdependence of energy-economy-environment; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Inter-fuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies: National and Sectoral energy planning; Integrated resource planning; Energy pricing.

Unit IV

Project Evaluation and Management

Financial analysis: Project cash flows, time value of money, life cycle approach and analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis, Network analysis for project management; Time estimation; Critical path determination; PERT, CPM and CERT; Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Funds planning; Project material management, evaluation and analysis; Implementation and monitoring; Performance indices; Case studies.

Text Books:

1. Polak, P., Systematic Errors in Engineering Experiments, Macmillan Press Ltd.
2. Holman, Jack P., Experimental Methods for Engineers, McGraw-Hill Book Company.
3. Doebelin, Ernest O., Engineering Experimentation – Planning, Execution, Reporting, McGraw-Hill.
4. David Cleland, Roland Gareis, Global Project Management Handbook: Planning, Organizing and Controlling International Projects, Second Edition, McGraw Hill Professional.
5. Jean Carlo Binder, Global Project Management: Communication, Collaboration and Management Across Borders, Gower Publishing, Ltd. Hampshire, UK.
6. Garth Ward, The Project Manager's Guide to Purchasing: Contracting for Goods and Services, Gower Publishing, Ltd. Hampshire, UK.
7. Denise Bower, Management of Procurement, Thomas Telford, London, UK.

Semester V
Module RET - 507
Energy Economics and Planning

Unit I

Energy Economics

Basic concept of energy economics ; Calculation of unit cost of power generation from different sources with examples; Eco-ground rules for investment in energy sector; Payback period, NPV, IRR, and benefit-cost analysis with example, Socio-economic evaluation of energy conservation programme; Net social benefit incorporating free riding concept and rebound effects.

Unit II

Economics and Renewable Energy Technologies

Overview of national energy use, energy supply and renewable energy programme during different plan periods, Relevance of economic and financial viability evaluation of renewable energy technologies, Basics of engineering economics, Financial feasibility evaluation of renewable energy technologies.

Unit III

Socio-economic Benefits of Renewable Energy Technologies

Social cost – benefit analysis of renewable energy technologies, Technology dissemination models, Volume and learning effects on costs of renewable energy systems, Dynamics of fuel substitution by renewable energy systems and quantification of benefits, Fiscal, Financial and other incentives for promotion of renewable energy systems and their effect on financial and economic viability.

Unit IV

Clean Development Mechanism (CDM)

Carbon finance potential of renewable energy technologies and associated provisions, Software for financial evaluation of renewable energy systems, Case studies on financial and economic feasibility evaluation of renewable energy devices and systems. Financial policies of the Government of India under Jawaharlal Nehru National Solar Mission.

Text Books:

1. Ferdinand Banks E., Energy Economics: A Modern Introduction, Kluwer, London.
2. Kandpal T.C., Garg H. P., Financial Evaluation of Renewable Energy Technology, Macmilan India Ltd. New Delhi.
3. Munasinghe M., Meier P., Energy Policy Analysis and Modeling, Cambridge University Press.
4. Samuelson P. A., William Nordhaus D., Economics, McGraw-Hill, New York.
5. Donnelly W. A., The Econometrics of Energy Demand: A Survey of Applications, Praeger, New York.
6. Dixon, et al, Economic Analysis of Environmental Impacts, Earthscan Publications Ltd., London.
7. Hackett Steven C., Sharpe M.E., Environmental and Natural Resources Economics, New York.
8. Thuesen G. J Fabrycky W. J., Engineering Economy, Prentice-Hall of India Pvt. Ltd.
9. White J. A., et. al., Principles of Engineering of Economic Analysis, John Wiley and Sons.
10. Dasgupta Ajit K, Pearce D. W., Cost Benefit Analysis, Theory and Practice, Macmilan.

Semester V
Module RET - 508
Energy Conservation and Management

Unit 1

Energy Conservation, Energy Management and Material and Energy Balance

Basic concepts, Energy conservation in household, transportation, agricultural, service and industrial sectors, Lighting, HVAC systems, Concept of energy management, energy demand and supply, economic analysis, Duties and responsibility of energy managers, Facility as an energy system of material and energy balance; Methods for preparing process flow, material and energy balance diagrams.

Unit 2

Energy Audit

Definition, need and types of energy audit, Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel and energy substitution; Energy audit instruments; Energy Conservation Act; Duties and responsibilities of energy managers and auditors.

Unit 3

Energy Action Planning, Monitoring and Targeting

Key elements; Force field analysis; Energy policy purpose, perspective, contents, formulation, ratification; Organizing the management: location of energy management, top management support, managerial function, roles and responsibilities of energy manager, accountability; Motivation of employees: Information system-designing barriers, strategies; Marketing and communicating: Training and planning, Defining monitoring and targeting; Elements of monitoring and targeting; Data and information-analysis; Techniques: energy consumption, production, cumulative sum of differences (CUSUM); Energy Service Companies ; Energy management information systems; SCADA systems.

Unit 4

Electrical Energy Management and Thermal Energy Management

Supply side: Methods to minimize supply-demand gap, renovation and modernization of power plants, reactive power management, HVDC, and FACTS. Demand side: conservation in motors, pumps and fan systems; energy efficient motors, Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management.

Text Books:

1. Smith C.B., Energy Management Principles, Pergamon Press, NewYork.
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case study, Hemisphere, Washington.
3. Krieder J., Rabi A., Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill.
4. Archie, Culp W., Principles of Energy Conservation, McGraw Hill.
5. Gellings C.W., J.H. Chamberlin, Demand-Side Management Planning, Fairmont Press.
6. Murphy, W. R. and Mckay G., Energy Management, Elsevier.

Semester V
Module RET - 509
Workshop Practices II

Black Smithy Shop:

- Study of tools & operations
- Simple exercises based on black smithy operations such as upsetting, drawing down, punching, bending.

Welding Shop:

- Study of tools and operations of Gas welding and Arc welding
- Simple butt and Lap welded joints.
- Oxy-acetylene flame cutting.

Sheet-metal Shop:

- Study of tools and operations.
- Making Funnel complete with 'soldering'.
- Fabrication of tool-box, tray, electric panel box etc.

Machine Shop:

- Study of Single point cutting tool, machine tools and operations.
- Plane turning.
- Step turning
- Taper turning.
- Threading

Foundry Shop:

- Study of tools and operations
- Pattern making.
- Mould making with the use of a core.
- Casting

Text Book:

1. S. K. Hajra Choudhury, Elements of Workshop Technology, Vol. II Asia Publishing House.

Semester VI
Module RET - 601
Industrial Training

Two months industrial training will be taken up by the students in the industrial setups of Industrial Partners identified in the B Voc (Renewable Energy Technology) Programme after the second year examination of B Voc Programme.

Semester VI
Module RET - 602
Major Project

The major project by the students will be taken up in Renewable Energy Technology areas with the help of Industrial Partners identified in the B Voc (Renewable Energy Technology) Programme during Semester - VI of the B Voc Year - 3 Programme.