Core (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 111	**Engineering Drawing**	**1 0 2**	**5**	**3**

Theory

Importance of Engineering Graphics, Drawing Instruments and their uses, Introduction to IS code of drawing; Conics and Engineering Curves – ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines – traces, true length; Projection of planes and solids; sold objects – cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids – true shape of section; Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

Practical

Orientation to various types of projections, First and Third angle systems of orthographic projections, types and use of lines and lettering, Dimensioning, Projection of Points in different quadrants, projections of lines and planes for parallel, perpendicular & inclined to horizontal and vertical reference planes. Drawing Projections and Cross-sections.

Orientation to Section planes, Sectional views, True shape of Sections for Prism, Cylinder, Pyramid, Cone & Sphere. An orientation to Auto CAD tools. Simple objects and Simple Machine Components like Bolts and Screw, different types of Lines and Free Hand Sketching, different types of lines in engineering drawing as per BIS specifications, practice in free hand sketching of vertical, horizontal and inclined lines, geometrical figures such as triangles, rectangles, small and large circles, parabolas, curves and ellipses. 2-D and 3-D solid modeling, orthographic, iso-metric projection drawing and sectional views of simple machine elements

Text Book:

1. *Engineering Drawing Plane and Solid Geometry*: N.D. Bhatt and V.M. Panchal, Forty-Fourth Edition 2002, Charotar Publishing House.
2. *Engineering Drawing*: Laxmi Narayan and Vaishwanar, Charotar Publishing House.
3. *A Text Book of Engineering Drawing*: S.B. Mathur, Second Revised and Enlarged Edition 2000, Vikas Publishing House.

Reference Book:

1. *Engineering Graphics and Drafting*: P.S. Gill, Millennium Edition, S.K. Kataria and Sons.
2. *Engineering Graphics using AUTOCAD 2007*: T. Jeyapoovan, First Edition 2002, Vikas Publishing House.
3. *Autocad 2008 instructor*: James A Leach, TMH New Delhi.
4. *Engineering Graphics with an introduction to Auto CAD*: D. Jolhe, TMH New Delhi.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 112	**Workshop Practice (RE)-I**	**0 1 2**	**5**	**3**

Theory

Introducing to various machine tools, Study of different vices, power hammer. Introduction to different welding processes. Introduction to different hand tools and wood turning lathe.

Practical

Carpentry shop – I

Making of various joints (Also draw the sketches of various wooden joints in the Practical Note Book)
Cross lap joint
T -lap joint
Comer lap joint
Mortise and tenon joint
Dovetail joint
Fabrication of utility items of farm tools by wood turning lathe

Fitting and Plumbing Shop – I

Demonstration on various machining process. Use of all important fitting shop tools with the help of neat sketches (files, punch, hammer, scraper, taps and dyes etc.) Making of simple jobs using chipping tools.
Practice on Oxy-acetylene gas welding and manual metal arc welding.
Practice of simple operation of hack saw in straight and angular cutting.
Practice of measuring tools used in fitting shop like: Try square, Steel rule, Measuring Tape, Outside micrometer, Vernier Caliper and Vernier Height Gauge
Cutting and filing practice on a square MS flat
Angular cutting practice of 45° (on the above job)
Preparation of stud (to cut external threads) with the help of dies (mm or BSW)
Drilling, counter drilling and internal thread cutting with Taps
Pipe cutting practice and thread cutting on GI Pipe with pipe dies

Text book:

1. *Workshop Technology Vol. I & II*, W. A. J. Chapman, E. Arnold, CBS, 4th Edition, 2001.
2. *Workshop Technology Vol. I & II*, B. S. Raghuwanshi, Dhanpat Rai & Sons, 5th Edition, 2001.

Reference Book:

1. *Manufacturing Process*, M. L. Begeman, B. H. Amstead, John Wiley & sons, 6th Edition, 1998.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 113	**Renewable Energy Technology-I**	**0 1 3**	**7**	**4**

Theory

Origin of the earth; Earth's temperature and atmosphere; Sun as the source of energy; Energy sources: classification of energy sources: conventional (coal, oil and gas) and renewable sources (solar, biomass, wind, hydro, geothermal, tidal, OTEC etc.); differentiates between conventional energy and nonconventional energy; quality and concentration of energy sources; World energy scenario; Fossil fuel reserves: estimation, India's energy scenario; energy and development linkage; Biological processes, photosynthesis, food chains; Ecological principles of nature, concept of ecosystems, different types of ecosystems, ecosystem theories; energy flow in the ecosystems; biodiversity.

Practical

Demonstration on conventional and nonconventional energy sources. Basic concepts: Terminology used in experimental methods i.e. sensitivity, accuracy, uncertainty, calibration and standards; experimental system design and arrangement;

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

Power generation – Wind mills, water wheels for shaft work, Industrial revolution – steam engine and coal fired boilers, Edison's invention of electricity, Thermal power plant, Electricity generator, electric motor, Economics of scale, super-critical power plants, Distributed generation. Measures of performance and comparison of efficiency and costs for these technologies. Transportation – Bullock car, bicycle, IC engine, Ford T, modern efficient IC engine, electric vehicle, fuel cell vehicle future car concepts – solar car, ethanol cars, lighting – candle kerosene lamp, incandescescent lamp, fluorescent lamps, solid state lighting, Design criteria, Material selection, Reasons for emergence of new technology, Identification of features propelling new developments, constraints imposed by fundamental basis, scarcity of energy resources and materials, Environmental constraints identification of trends. Use of sensors and instrumentation to quantify performance of energy devices.

Text Book:

[1] Kaushika N. D. and Kaushik K., *Energy, Ecology and Environment:A Technological Approach*, Capital Publishing, 2004.

[2] De A. K.; *Environmental Chemistry*, New Age International, 2005.

Reference Book:

[1] Sorensen B.; *Renewable Energy*, Fourth Edition, Academic press, 2010.

[2] Sarkar S.; *Fuels and Combustion*, Third Edition, Universities Press, 2009.

[3] Johannson T. B., Kelly H., Reddy A. K. N. and Williams R. H. (Ed), *Renewable Energy: sources for fuel and electricity*, Island Press, Washington DC, 1993.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 114	**Renewable Energy Laboratory-I**	**0 1 4**	**9**	**5**

Theory

Introduction to Solar radiation and its measurement, extra-terrestrial and terrestrial radiation, physical principles of conversion of solar radiation into heat, basics of solar energy conversion to electricity; basic working principles of solar cooker, design available in the market, information of solar cooker manufacturer in India, introduction of solar cooker for industry and community application, introduction to different types of biomass conversion systems, introduction to biogas production and utilization.

Practical

Study solar cooker design and components, assemble solar cooker, study the general maintenance schedule for solar cooker, fault finding and trouble shooting. Study solar photovoltaic module, assembling of solar lighting systems, dismantle every part of solar lantern, study the construction and function of solar parts, test for fault finding, dismantle solar home lighting systems, study the construction, function of each part. Field study of different working and non-working models of biogas plants. Study the operating systems of a biogas systems, construction materials and constructions module of biogas plant, raw materials, mixing and feeding, feed inlet and outlet, gas utilization, gas pressure, slurry utilization of a biogas plant. Design principle and working of biomass cooking stove, traditional and improved cooking stove, indoor air pollution, orientation to different cook stove design, performance testing of cook stove.

Text Book:

1. Nayak J. K. and Sukhatme S. P. (2006), *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill.
2. Solanki C. S. (2009); *Solar Photovoltaics: Fundamentals, Technologies and Applications*, Prentice Hall India.

Reference Book:

1. Nijaguna B. T. (2006). *Biogas Technology*, New Age International.
2. BanwariLal (2011). *Wealth from Waste*, Third Edition, Published by TERI Press, 2011, ISBN 10: 8179934241 / ISBN 13: 9788179934241.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 112	**Introductory Microbiology**	**3 0 0**	**3**	**3**

Unit 1 History of development of Microbiology

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis, development of various microbiological techniques, concept of fermentation, establishment of fields of medical microbiology, immunology and environmental microbiology.

Unit 2 Diversity of Microbial world

A. Systems of classification

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms **B. General characteristics of different groups**:

Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance. **Viruses, viroids and prions**

A general introduction with special reference to the structure of the following: TMV, poliovirus, T4 and λ phage, lytic and lysogenic cycles, one step multiplication curve

Bacteria

A very precise account of typical eubacteria, chlamydiae&rickettsiae (obligate intracellular parasites), mycoplasma, and archaebacteria (extremophiles).

Algae

History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cell ultra-structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Detailed life cycle of *Chlamydomonas*and *Spirogyra*.

Fungi

Historical developments in the field of Mycology including significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Detailed life cycle of Aspergillus and Rhizopus.

Protozoa

General characteristics with special reference to Amoeba, Paramecium and Giardi.

Text Book:

1. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM. T. Brown Publishers.
2. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education limited.

Reference Book:

1. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition. Pearson Education.
2. Vashishta BR and Sinha AK. (2008). *Fungi*. S. Chand and Company Ltd.
3. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th Edition, McGraw Hill Higher Education.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 113	**Industrial Microbiology**	**3 0 0**	**3**	**3**

Unit I

Exploitation of microorganisms and their products, screening, strain development strategies, immobilization methods, fermentation media, raw material used in media production, antifoaming agents, buffers, downstream processing.

Unit II

Fermentation equipment and its uses, fermentor design, Types of fermentors and fermentations- single, batch, continuous, multiple, surface, submerged and solid state.

Unit III

Industrial products from microorganisms- antibiotics: production of penicillin, streptomycin. Interferons, vaccines, hormones, vitamins.

Unit IV

Enzymes from microbes: amylase, protease. Organic acids: citric acid, acetic acid, amino acids: glutamic acid, lysine.

Unit V

Production of alcoholic beverages: beer and wine, biofuels: ethanol, methane, biogas.

Text Book:

1. Patel A.H., *Industrial Microbiology*, Macmillan India Limited, 2nd edition, 2011.
2. Sharma S., *Industrial Microbiology*, Anmol publication Pvt. Ltd, 2011.

Reference Book:

1. Kango N., *Textbook of Microbiology*, I.K. International Publishing House Pvt. Ltd, 2009
2. Okafor Nduka, *Modern Industrial Microbiology and Biotechnology*, CRC, 2007.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 114	**Environmental Microbiology**	**3 0 0**	**3**	**3**

Unit I

Aerobiology: droplet nuclei, aerosol, assessment of air quality, airborne diseases and their control, enumeration of microbes from air. **Unit II**

Soil Microbiology: soil microflora and its enumeration, rhizosphere, phyllosphere, microbial interactions, mycorrhizae, lichens. **Unit III**

Nitrogen fixation: mechanism of symbiotic and asymbiotic, nitrogenase complex, nif genes and their regulation, *Rhizobiaceae, Frankia*.

Unit IV

Biogeochemical cycling: role of microorganisms in carbon, nitrogen, phosphorus and sulfur cycles. Biodegradation of xenobiotics, bioaccumulation, biodeterioration.

Unit V

Water microbiology: ecosystems – fresh water and marine, zonations, eutrophication, water borne diseases and their control. Waste treatment – solid liquid, aerobic and anaerobic methods.

Text Book:

1. Singh D.P. and Dwidvedi S.k., *Environmental Microbiology and Biotechnology*,New Age International Pvt. Ltd., 2004.
2. Mohapatra P.K. *Textbook of Environmental Microbiology*, I. K. International Publishing House, 2008.

Reference Book:

1. Maier R. M., Pepper I.L. and Gerba C.P, *Environmental Microbiology*, Academic Press Inc, 2nd edition, 2008.
2. Rochelle P.A., *Environmental Molecular Microbiology: Protocals and Application*, Garland Science, 2001.

Core (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 121	**Basic Electrical Systems**	**2 0 1**	**4**	**3**

Unit-I

Overview on Basic Electricity: Characteristic of electricity, Understands electron and proton, phase and neutral wire with figure (description in simple way by giving example). Understands electrical symbols used in system, understands Laws of electricity, understands electrical safety (electric shock). Understands various methods for the generation of electric current. Definitions of Current, Voltage, Power, Circuit elements, Ohm's law, Kirchoff's law, Nodal Analysis, Mesh Analysis, introduction to electric circuit, AC and DC current, understands series and parallel connection, understands power, energy, resistance of wires made of different materials, importance of resistance, various wirings such is used more now a day, Faults in wiring and effects. Importance of earthing in a wiring, various types of earthing and the type of earthing used now a days.

Source transformations, linearity and Superposition, Thevenin's and Norton's Theorems, Maximum power transfer theorem, Star-Delta and Delta-Star Conversion, Simple RL and RC Circuits, Unit Step Forcing Function, source free RLC Circuits, Sinusoidal Forcing Function, Complex Forcing Function, Phasor Concept, Impedance and Admittance, Phasor diagrams, Response as a Function of , Instantaneous Power, Average Power, RMS values of Current and Voltage, Apparent Power and Power Factor, Complex Power, Introduction to Three Phase Circuits.

Unit-II

Working principle of Transformer, Principle of DC Generator and Motor.

Unit-III

Working principles of Moving Coil, Moving Iron and Electrodynamic Meters.

Unit-IV

Troubleshooting in domestic wiring system; Study of a distribution board for domestic installation; Use of ammeter, voltmeter, wattmeter, energy meter and multi-meter; Ohm's Law verification; Verification of law of resistance in series; Verification of law of resistance in parallel; Study of different types of fuses; Practice of earthing and various types of earthing, applications of MCBs and ELCBs.

Practical:

1. Demonstration on various safety measures.
2. Study and applications of various electrical symbols used.
3. Demonstration on verification of various Laws.
4. Study and practice on various electrical circuits.
5. Practice on various earthing systems.
6. Experiments on Circuits: Verification of Network Theorems, Design and Study on circuits using R, L and C, Power measurement in single phase A.C. Circuits.
7. Transformer: Open circuit and Short Circuit Tests.
8. D.C machines: Open Circuit Characteristic of Generator, Speed Control of D.C. motors.
9. Electrical Measuring Instruments: Calibration of meters, Power measurement in 3-phase circuits, AC bridges.
10. Power System: Design and Physical model of domestic wiring

Text Book:

1. Hayt W H and Kemmerly J E, *Engineering Circuit Analysis*, McGraw Hill, 1993
2. Toro V. D. *Electrical Engineering Fundamentals*, PHI, 1994
3. Kothari D.P. and Nagrath I.J, *Basic Electrical Engineering*, Mc Graw-Hill, 2nd Edition, 2002

Reference Book: 1. Golding and Widdis, "*Electrical Measurements and Measuring Instruments*", A H Wheeler & Co., Kolkata, 1993
2. H Cotton, "*Advanced Electrical Technology*", Issac Pitman, London.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 122	**Workshop Practice (RE)-II**	**0 1 2**	**5**	**3**

Welding Shop

Preparation of Lap joint by arc welding
Preparation of Butt joint by arc welding
Preparation of T-joint by arc welding
Preparation of single V or double V butt joint by using Electric arc welding
Gas welding practice on worn-out and broken parts
Fabrication of truss or grill.

Electric Shop

Wiring practice in batten wiring, plastic casing-capping and conduit
Control of one lamp by one switch
Control of one lamp by two switches
Control of one bell by one switch
Assemble a Tube light
Dismantle, study, find out fault, repair the fault, assemble and test domestic appliances like electric iron, electric mixer, ceiling and table fan, tube-light, water heater (geyser) and desert cooler Laying out of complete wiring of a house (Single-phase and Three phase)

Turner

Introduction of Lathe machine, its functions and types of lathe machine, Different lathe tool geometry: Single point cutting tool, Threading tool, Boring tool, Grooving tool etc.
Practice different lathe machines operations: Straight turning, Step turning, facing, Taper turning, Chamfering, Knurling, External Thread cutting, Grooving etc.
Special lathe operations like Drilling, Boring, Counter boring, Taper boring, Eccentric Turning, Internal tread cutting etc.
Practice on Drilling machine, Grinding machine and Power Hacksaw machine. Maintenance work on lathe machine, Drilling machine and Power hacksaw machine.

Text Book:

1. Choudhury S. K. H. *Elements of Workshop Technology*, Vol. II Asia Publishing, 2006.
2. Chapman W. A. J. and Arnold E. *Workshop Technology Vol. I & II*, CBS, 4th Edition, 2001.

Reference Book:

1. Raghuwanshi B.S, *Workshop Technology Vol. I & II*, Dhanpat Rai & Sons, 5th Edition, 2001.
2. Begeman M. L. and Amstead B. H, *Manufacturing Process*, John Wiley & sons, 6th Edition, 1998.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 123	**Renewable Energy Technology-II**	**0 1 3**	**7**	**4**

Basic working principle of solar water heater, design available in market and India, Installation of SWHs, different types of collectors-Flat plate, concentrating, selective absorber coating;
Basics of Solar Photovoltaic: principle of photovoltaic conversion; safety measures of a solar photovoltaic system,
Biomass thermal conversion: biomass gasification, different types of biomass gasifier, overview of biomass gasifier based power production and utilization.
Wind energy conversion systems: classification, applications, power, torque and speed characteristics.
Small Hydropower Systems: Introduction to different types of Hydropower Plants, Selection of site for hydroelectric plant, Essential elements of hydroelectric power plant, Economics: cost structure, Initial and operation cost.

Practical

Study on Solar Water Heater (SWH) designs and components. Orientation and installation of SWH for hot water generation. Knowledge about dimension and quality of steel sheets used for making hot tank outer and inner, practice of sheet cutting by shearing machine, selecting correct templete, checking shearing edge; checking the nos. of punches to be made, numbers of tubes to be inserted, dimensions of punch to be required, stopper setting before operations; identify the tank dimension- inner and outer, knowledge on fitting the inner and outer tank, insulating the water tank, use of insulating materials, foam making materials inside the tank, study the collectors-materials use, hot water circulation from collector to tank.
Biomass gasifier, Orientation to different parts, design specification, air inlet and gas outlet, gas cleaning and cooling systems, dismantling of different parts and reassembling, hopper size and feeding, feed materials size to gasifier types, orientation to open and close top gasifier.
Knowledge about wind data, wind power generating systems, wind based mechanical power etc.
Study detail the operation of Small Hydropower (SHP), different components, their maintenance schedule, fault finding and trouble shooting.

Text Book:

1. Ramlow Bob, *Solar Water Heating: A Comprehensive Guide to Solar Water and Space Heating Systems*. New Society Publishers, 2006.
2. Singh S. C. Solar *Photovoltaics: Fundamentals, Technologies and Applications*. ISBN-10: 8120343867/ISBN-13: 978-8120343863, PHI 2011.
3. Singh S. C. *Renewable Energy Technologies: A Practical Guide for Beginners*. ISBN-10: 8120334345/ISBN-13: 978-8120334342, PHI 2008.
4. Mukherjee D. and Chakraborty S. *Fundamentals of Renewable Energy Systems*. ISBN: 81-224-1540-7. New Age International. New Delhi, reprint 2005.

Reference Book:

1. *MNRE publication: Solar Thermal Systems Module Trainers Textbook. Study materials in Renewable Energy Areas for ITI students.* Ministry of New and Renewable Energy, Government of India. New Concept Information Systems Pvt. Ltd.
2. *MNRE publication: Solar Lighting Systems Module Trainers Textbook. Study materials in Renewable Energy Areas for ITI students*. Ministry of New and Renewable Energy, Government of India. New Concept Information Systems Pvt. Ltd.

3. Prabir Basu; *Biomass Gasification and Pyrolysis-Practical Design*. ISBN: 978-0-12-374988-8, Elsevier 2010.
4. Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi: *Wind Energy Handbook*. ISBN 1119992729/ 9781119992721. Wiley, 2011.
5. *MNRE publication: Small Hydropower Module Trainers Textbook. Study materials in Renewable Energy Areasfor ITI students*. Ministry of New and Renewable Energy, Government of India.New Concept Information Systems Pvt. Ltd.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 124	**Renewable Energy Laboratory-II**	**0 1 4**	**9**	**5**

Theory

Introduction to photo voltaic cell, advantages and disadvantages of photo-voltaic conversion. Uses of solar cell in various instruments. Photo-voltaic array and its connections, arrangements of array according to the voltage. Module and its connections. Faults and their effects in photo voltaic cell, array and module (connection of cell, connection of array, connection of module).

Fuels - Characteristics and Properties. Combustion Thermodynamics and Thermo-chemistry- Heat of Reaction, Calorific Value, Adiabatic Flame Temp. etc.

Practical

Solar: Measurement of solar radiation and sunshine hours, Measurement of albedo, UV & IR radiation,, Orientation to earthing in a wiring, various types of earthing and the type of earthing used now a days. Prepare a wiring using various accessories in solar electricity and perform its testing, Make series and parallel wiring in solar electricity and pare a table of equations of voltage and current. To study the faults and their remedies in the wiring in solar electricity. Make an array using photo-voltaic cell in solar electricity. In solar electricity, prepare modules of various capacities with the help of array.

Biomass: Experimental study on thermal performance and efficiency of biomass downdraft gasifier and sampling, measurement of the calorific value of different Bio-mass fuels , Process orientation to Liquid bio-fuel production and characterization;

Fuel: Determination of Density, Viscosity, Flash-point, Fire-point Pour-point, ASTM distillation of liquid fuels; Proximate and Ultimate analysis, calorific value of solid fuels.

Instrumentation and control: Introduction to use of microprocessor kit, microcontroller, data acquisition and display experiments.

Text Book:

1. Deambi S. From *Sunlight to Electricity: A Practical Handbook On Solar Photovoltaic Applications*, Second Edition, The Energy and Resources Institute, 2008, ISBN-13, 9788179931561.
2. Sarkar S. *Fuels and Combustion, Universities* Press, 1974, 3rd Edition, ISBN 8173716692, 9788173716690.

Reference Book:

1. Mani A., *Hand book of solar radiation data in India*, Allied publisher pvt. Ltd., 1980.
2. *Solar Electricity Handbook - 2013 Edition: A Simple Practical Guide to Solar Energy -Designing and Installing Photovoltaic Solar Electric Systems Paperback* – December 5, Michael Boxwell (Author), ISBN-13: 978-1907670282 ISBN-10: 1907670289 7th Edition, 2012.
3. Goswami D. Yogi ed. *Alternative Energy in Agriculture, Vol. II*, CRC Press, 1986,
4. Basu P. *Biomass Gasification and Pyrolysis- Practical Design*, ISBN: 978-0-12-374988- Elsevier.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 122	**Biomolecules**	**3 0 0**	**3**	**3**

Unit I: Introduction to Bio-chemistry, water as a biological solvent. Dissociation of water, Buffer solution. Henderson Hasselbatch Equation.

Unit II: Structure, function and properties of proteins: Amino acids, common structural features, Physical and chemical properties of amino acids. Classification based on the nature of "R" group. Amino acids present in protein and non-protein amino acids. Peptide bonds, Protein, level of Protein structure, structural and functional diversity of protein.

Unit III: Structure, function and properties of carbohydrates: Definition and classification of carbohydrates. Fisher and Haworth structure of carbohydrates. Sterioisomerismnadmutarotation. Anomeric forms of monosaccharides, derivatives of monosaccharides, homo and hetro-polysaccharides (structure of amylase, amylopectin, starch, dextrins etc.)

Unit IV: Structure, function and properties of lipids: definition and classification of fatty acids (saturated and unsaturated). Essential acids, Important reactions of functional groups present in the fatty acids. Characteristics of fatty acids and fats; Triacylglycerols, phospholipids lecithins, lysolectins, lipoproteinscomposition,classification and biological functions, terpenes and steroids-terpenes of biological significance e.g. carotenes, phytol, Cholesterol and other amino sterols; Structrure, Sources and biochemical functions of fat soluble vitamins.

Unit V: Structure, function and properties of nucleic acids: Nucleic acids, structure and properties of purine and pyrimidine bases, Nucleosides and Nucleotides, Biological important nucleotides, Double helical model of DNA and forces responsible for it, physical and chemical properties of nucleic acid.
Unit VI: Bioenergetics and metabolism: Principles of Bioenergetics, Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway, The Metabolism of Glycogen in Animals, The Citric Acid Cycle.

Text Book:

1. Harbans Lal: *A Textbook of Biochemistry*, – 1 Jan 2011 ISBN-10: 8123920393.
2. Lehninger A.L, *Principles of Biochemistry*, 4th edition, W.H Freeman and Company, 2004.

Reference Book:

1. Voet and J.G.Voet, *Biochemistry*, 3rd edition, John Wiley, New York, 2004.
2. Stryer L., *Biochemistry*, 5th edition, W.H. Freeman and Company, 2002.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 123	**Enzyme Technology**	**3 0 0**	**3**	**3**

Unit I: Enzymes:
Introduction to enzymes, Early Enzyme Discoveries, Enzyme Structure, Specification of Enzymes, Enzyme characteristics and properties, Enzyme nomenclature/classification, Enzyme Specificity, Purification & Characterization Of Enzymes, Enzyme Assay, Enzyme Engineering.

Unit II: Enzyme kinetics:
Basic Enzyme reaction, Catalysis in Non-Aqueous Solvent, Bioenergetics, Introduction to Metabolism, knzyme kinetics, Single substrate Enzyme inhibition, Kinetics of multisubtrate Enzymes, Enzyme's regulation and cooperativity, Enzymes immbilsation techniques, Enzyme biosensor.

Unit III: Mechanism of enzyme catalyst
Reaction Mechanisms and Catalysis, Active Site studies, Specific enzymes Case examples of enzymes.

Unit IV: Enzyme regulation
Partial Proteolysis, Phosphorylation, adenylylation, disulphide reduction, Allosteric regulation.

Text Book:

1. Nooralabettu K.P., *Enzyme Technology: Pacemaker of Biotechnology,* Phi Learning, 2011.
2. Bhatt S.M., *Enzymology and Enzyme Technology*, S. Chand, 2014.

Reference Book:

1. Harrow, B., and Mazur, A., *Textbook of Biochemistry*, 109, Saunders, Philadelphia, 1958.
2. Holum, J., *Elements of General and Biological Chemistry*, 2nd edition, 377, Wiley, NY, 1968.

Elective (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VC 124	**Microbial Technology**	**3 0 0**	**3**	**3**

Unit I: Bioreactor design and operation
Designing of bioreactors , Immobilized cell reactors and air-lift reactors – Design and operation.

Unit II: Aeration and agitation
Aeration - Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics (Oxygen Uptake Rate – OUR; Oxygen Transfer Rate OTR).
Agitation - Functions of agitation. Flow patterns with different types of impellers.
Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and nonNewtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, Power number.

Unit III: Monitoring of process variables, Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO2), Basic principles of operation, types of biosensors.

Unit IV: Growth and product formation during fermentation
Concept of primary, secondary metabolites and their control, Kinetics of growth and product formation (growth rate, yield coefficient, efficiency etc.) Operational modes of bioreactors:
Batch, Fed-batch and Continuous processes: Applications, advantages and limitations of each type.

Unit V: Effect of type of growth on fermentation
The type of growth (mycelial pellet form, mycelial filamentous form, free cell, cells producing exopolysaccharides) affects mass transfer of nutrients, oxygen and heat; as also cell proliferation can be affected by shearing of cells. At least one example of each type may be explained to show these effects in any suitable fermentation.

Text Book:
1. Peppler H.J and Perlman D., *Microbial Technology*, Academic Press, 1979.
2. Mukerji K.G. and Gupta R., *Microbial Technology*, APH, 2001.
2. Peppler H. J. and D. Perlman, *Microbial Technology Volume 1 and 2*, Academic Press New York, 1970.

Skill (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
GC 211	**Communication skill-I**	**1 3 0**	**4**	**4**

Writing

HOW - Writing short notes on article/reports, notes on lectures (talks from TV/radio)

Writing notice (both formal/informal/friendly), interpreting pictures, advertisements, visuals (print/electronic) and writing briefly about them (Instructions: express ideas in clear and grammatically correct English, using appropriate punctuation and cohesion devices; write in a style appropriate for communicative purpose; plan, organize and present ideas coherently by introducing, developing and concluding a topic; compare and contrast idea and arrive at conclusions; identify rules underlying good writing; Write different kinds of writing such as writing a good CV, formal/informal letter, academic writing, proceedings of seminar, etc.; develop skills for revision and editing; design content writing)

Listening

Adopt different strategies according to the purpose of listening (pleasure/general interest/specific information; use linguistic and non-linguistic features of the context as clues to understanding and interpreting what is heard (cohesion devices/key words/ intonation/gesture/background noises) ; listen to a talk or conversation and understand the topic; listen to information required for a specific purpose (radio broadcast/commentaries/classroom lecture/railway or airport announcement, etc.); understand and respond appropriately to directive language (instruction/advice/requests/warning, etc.); understand and interpret spontaneous spoken discourse in familiar social situations.

Text book:

1. Hyland, K. 2002. *Teaching and researching writing*. New York: Longman. ISBN: 0-582-42338.
2. Grabe, W. and R. Kaplan. 1996. *Theory and practice of writing: An applied linguistic perspective*. New York: Longman. ISBN: 0-582-55383-0.
3. Mendelsohn, D. 1994. *Learning to listen: A strategy-based approach for the second language learner*. San Diego, CA: Dominie Press. ISBN: 0-56270- 299-8.
4. Flowerdew, J., ed. 1994. *Academic listening*. New York: Cambridge University Press. ISBN: 0-52145551-0.

Reference Book:

1. Tribble, C. 1996. *Writing*. New York: Oxford University Press. ISBN: 0-19- 437141-7.
2. Brown, G. 1995. *Speakers, listeners, and communication*. New York: Cambridge University Press. ISBN: 0-521-58705-0.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 212	**Solar Energy Systems**	**0 1 2**	**5**	**3**

Solar radiation: extra-terrestrial and terrestrial, Radiation measuring instruments, Radiation measurements and predictions.
Solar thermal and photovoltaic operation, solar thermal devices their operations, repair and maintenances
i.e. solar cookers, steam solar cooker, advanced solar cooker, solar dryer, solar tunnel dryer, solar desalination, solar water heater for industrial use, solar oven, solar thermal electricity generation options, solar refrigeration & air conditioning, solar houses active & passive cooling & heating. Hybrid solar and conventional water heating system and their operations, repair and maintenance
Principle of photovoltaic conversion, Technology for fabrication of photovoltaic devices, Photovoltaic power generation systems, Off-grid systems, Grid connected systems.

Practical
Study of a box type solar cooker, solar steam cooker, solar dryer, solar distillation plant, solar furnace, solar water heater, solar PV system and different batteries used in PV system, Performance evaluation of solar PV pumps for lighting power etc. Design and construction of box type solar cooker, solar distillation plant, direct and indirect solar dryer. Repair and maintain of solar cooker, solar water heater and solar dryers etc.
Identifying current location of the solar modules, correct installation practice, correct location for charge controller and batteries and visual indications in charge controller and check for proper functioning
Wiring plan and location of loads and charge controllers and modules to avoid loss
Fabrication and evaluation methods of solar cells, study of VI characteristics of solar PV system.

Text Book:

1. Goswami D.Y, Kreith F, Kreider J.F, *Principles of Solar Engineering*, Taylor & Francis, 1999
2. Tiwari G.N, *Solar Energy, Fundamentals design, modeling and Applications*, Narosa, 2002

Reference Book:

1. Duffie J.A, Beckman W.A, *Solar Engineering of Thermal Processes*, John Wiley, 2006
2. Kishore V.V.N, *Renewable Energy Engineering and Technologies*, TERI, 2009.
3. *Photovoltaics: Design and Installation Manual, Solar Energy International*, New society publishers, 2004.

Skill(VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 213	**Biomass Conversion Technologies**	**0 1 3**	**7**	**4**

Overview of biomass as energy source; Biomass availability in North Eastern States of India, Production of biomass, Photosynthesis, efficiency of C3 & C4 plants on biomass production, Classification of biomass, Physicochemical characteristics of biomass as fuel, Biomass conversion routes: biochemical, chemical and thermo-chemical. Anaerobic digestion, biogas production mechanism, Types of digesters, installation, operation and maintenance of biogas plants, Pyrolysis, Carbonization, Charcoal production, bio-oil production and utilization, Biomass gasification--different types--power generation from gasification, Biomass based power generation, Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization, Alcohol production from biomass- types of materials of alcohol production-process description, utilization. Overview on energy plantation, Basis of selecting the plants for energy plantation, Waste land utilization through energy plantation.

Practical

Study of biomass densification i.e. pelletisation, briquetting and cubing machine, Operation and Maintenance of KVIC biogas plant, Deenbandhu biogas plant, identification the defects in biogas plant and its repair, user practice of biogas appliances, design of improved cooking stoves & performance evaluation. Determination of calorific value of biogas, Analysis of biogas to determine its constituents and Study of producer gas generators such as open core, throat type for shaft power production and thermal application. Study of incinerator and co-generators for power production. Biodiesel production from different feedstock. Preference of CI engine with biodiesel. Alcohol production methods.

Text Book:

1. Mukunda H.S, *Understanding Clean Energy and fuels from biomass*, Wiley-India Pvt. Ltd, 2011.
2. Pandey A, *Hand book of plant based biofuel*, CRC Press, Taylor & Francis, 2008.

Reference Book:

1. Mital K.M, *Biogas Systems, Principle and Applications*, New Age International Ltd. 1996
2. Rai G.D, *Nonconventional energy sources*, Khanna Publication, 2001
3. Ravindranath N.H, Hall D.O, *Biomass, Energy and Environment: A developing country perspective from India*, Oxford University Press,
4. Kothari D.P., Singal K.C. and Ranjan Rakesh, *Renewable Energy Sources and Emerging Technologies*, PHI, 2011.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 214	**Farm Power**	**0 1 4**	**9**	**5**

Thermodynamics and Energy Conversion: Basic concepts, Zeroth law and temperature, Energy interaction, First Law, Flow processes, Second Law, Entropy and availability, Combined First and Second Laws, Gas Power cycles: Carnot, Stirling, Brayton, Otto, Diesel and Duel cycles, Vapour power cycles: Rankine cycle and improvements, Refrigeration, Psychrometry, Role of thermodynamics in Energy conversion.

History and Fundamental Principles of the Diesel Engine, Diesel Engine Combustion, Fuel Injection Systems, Introduction to basic machine tools, various types of machine tool drives, their mechanisms, transmission and manipulation Gear box design Thumb rules for designing machine elements Design of hydraulic system Specifications of hydraulic valves, piping, pumps and tanks Design of electrical circuits Elementary NC and CNC programme.

Practical

Identification of various types of diesel engines, Identification of various tools used for dismantling and assembling IC engines, Performing pre-starting checks on engine, Engine dismantling and inspection of various parts, measurements of clearances, Engine assembly and trouble shooting, Practice of fitting of different Flat and V -belt drives, various adjustments such as length, ratio etc. Study of belt dynamometer.

Valve system – study and adjustments, Oil & Fuel - determination of physical properties, Study of Air cleaning system. Study of Fuel supply system of CI engine. Study of Cooling system: thermostat and radiator. Study of Lubricating system. Study of engine performance curves. Visit to engine manufacturer/ assembler/ spare parts agency.

Text Book:

1. Nag P.K., *Engineering Thermodynamics*, Tata Mc-Graw Hill, New Delhi, 1991.
2. Mollenhauer, Klaus, Tschöke, Helmut (Eds.). *Handbook of Diesel Engines*, Springer.
3. Joshi P.H, *Machine Tools Handbook: Design and Operation*, Tata McGraw Hill Education (2007).

Reference Book:

1. Bejan A, *Advanced Engineering thermodynamics*, John Wiley, Toronto, 1988.
2. Dempsey P., *Troubleshooting and Repair of Diesel Engines*, McGraw-Hill Professional; 4th edition, 2007.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 215	**Fuel Technology**	**1 0 2**	**5**	**3**

Unit I: Basics of Fuel

Energy and energy resources, Conventional and Non-conventional energy resources, Energy: Consumption and demand, Basics of fuels: Modern concepts of fuel, Solid, liquid and gaseous fuels.

Unit II: Solid Fuel

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

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

Unit III: Liquid Fuel

Petroleum as a source of energy and chemicals: Origin, composition, classification of petroleum, grading of petroleum; Processing of petroleum: Distillation of crude petroleum, petroleum products, purification of petroleum products – thermal processes, catalytic processes, specifications and characteristics of petroleum products, Storage and handling of liquid fuels. Liquid fuels from sources other than petroleum.

Unit IV: Gaseous Fuel

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

Unit V: Combustion Process and Properties

Principles of combustion: Chemistry and Stoichiometry, thermodynamic analysis and concept of adiabatic flame temperature, Combustion appliances for solid, liquid and gaseous fuels: working, design principles and performance analysis.

Emissions from fuel combustion systems: Pollutants and their generation, allowed emissions, strategies for emission reduction.

Text Book:

[1] Sarkar S. (2009); *Fuels and Combustion*, Third Edition, Universities Press [2]
Sharma S. P. and Chander M. (1984); *Fuels and Combustion*, Tata McGraw Hill.

Reference Book:

[1] Mukunda H. S. (2009); *Understanding Combustion*, Second Edition, Universities Press.
[2] Turns S. (2011); *An Introduction to Combustion: Concepts and Applications*, Third Edition, McGraw Hill.
[3] Glassman I. and Yetter R. (2008); *Combustion*, Fourth Edition, Academic Press.
[4] Sharma B. K. (1998); *Fuels and Petroleum Processing*, First Edition, Goel publishing.
[5] Gupta O. P. (1996); *Elements of Fuels, Furnaces and Refractories*, Third Edition, Khanna Publishers.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 216	**Basic Thermodynamics**	**1 0 2**	**5**	**3**

Unit I: System and Continuum

Intensive and Extensive properties – Thermodynamic state, pressure, energy, work and heat – process and cycle – Macroscopic and Microscopic points of view – Kinetic theory of gases.

Unit II: Laws of thermodynamics

Zeroth law – Concept of equilibrium – Principles of thermometry – Fixed points.

First law of thermodynamics and its application to open and closed systems – Concept of internal energy – Steady flow energy equation – Processes of closed systems.

Second law of thermodynamics – Various statements – Carnot cycle – Irreversible and Irreversible processes – Thermodynamic efficiency and temperature scales – Concept of entropy – Entropy changes in various processes.

Unit III: Properties of steam:

Latent heat – Saturation pressure and temperature – Dryness fraction – Degree of superheat – Total heat; Rankine cycles.

Unit IV: Air standard cycles

Otto, Diesel – Principles of working and description of two and four stroke SI and CI engines – Representations of processes on T-S and p-v diagrams.

Unit V: Fuels and Combustions

Classification of fuels; HCV, LCV, Bomb Calorimeter, Boy's gas calorimeter; Combustion of fuels; Minimum air required (by weight and by volume); Conversion of volumetric analysis into weight analysis and vice verse; excess air and Orsat apparatus.

Text Book:

1. Nag P.K., *Engineering thermodynamics*, Tata McGraw Hill Publication, 2014.
2. Cengel Y.A. and Boles M.A., *Thermodynamics: An Engineering Approach*, Tata McGraw Hill Publication, 4th edition, 2001.
3. Rathakrishnan E., *Fundamentals of Engineering Thermodynamics*, PHI, 2nd edition, 2005.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 217	**Energy Storage System**	**1 0 2**	**5**	**3**

Energy Demand and Storage, Different types of energy storage; Mechanical, Chemical, Biological, Magnetic, Thermal energy storage, Comparison of energy storage technologies Thermal energy storage: principles and applications, Sensible and Latent heat, Phase change materials; Energy and exergy analysis of thermal energy storage, solar energy and thermal energy storage.

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

Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells; Thermodynamics of fuel cells; Fuel cell types: AFC, PAFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance, characterization and modeling; Fuel cell system design and technology, applications for power and transportation

Battery: fundamentals and technologies, characteristics and performance comparison: Lead acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries
Application of Energy Storage: Food preservation, Waste heat recovery, solar energy storage: Greenhouse heating; Drying and heating for process industries

Text Book

[1] Huggins R., *Energy Storage*, Springer, 2010.
[2] Zobaa A.F., *Energy Storage-Technologies and Application*, InTech, 2013.

Reference Book

[1] O'Hayre R. Cha S. Colella W. and Prinz F. B., *Fuel Cell Fundamentals*, Second Edition, Wiley, 2009. [2] Narayan R. and Viswanathan B., *Chemical and Electrochemical Energy System*, Universities Press, 1998.
[3] Cabeza L.F., *Advances in Thermal Energy Storage Systems: Methods and Application*, Woodhead Publishing, 2014.
[4] Rahn C. D. and Wang C., *Battery Systems Engineering*, First Edition, Wiley, 2013. [5] Tiwari G. N., Greenhouse Technology for Controlled Environment, Narosa, 2012.

Core (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 221	**Wind and Hydro Energy**	**2 1 0**	**3**	**3**

Unit I: Introduction to wind energy

Introduction to wind energy, Current status and future prospects, Power available in wind spectra, Classification of wind turbines, characteristics of wind rotors, aerodynamics of wind turbine, rotor design and performance.

Unit II: Wind energy Conversion systems

Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind resource assessment, Weibull distribution, Betz limit, Wind energy conversion systems: classification, applications, power, torque and speed characteristics

Aerodynamic design principles; Aerodynamic theories: Axial momentum, Blade element and combine theory, Rotor characteristics, Maximum power coefficient, Tip loss correction, Wind turbine design considerations: methodology, theoretical simulation of wind turbine characteristics, test methods Wind pumps, performance analysis of wind pumps, design concept and testing, Principle of WEG: stand alone, grid connected; Hybrid applications of WECS; Economics of Wind energy utilization, Wind energy in India, Case studies. Wind energy and environment.

Unit III: Hydro-energy

Hydrology, Resource assessment, Potential of hydropower in India, Classification of Hydropower Plants,

Small Hydropower Systems: Overview of micro, mini and small hydro systems, Status of Hydropower Worldwide and India

Hydraulic Turbines: types and operational aspects, classification of turbines, elements of turbine, selection and design criteria, geometric similarity operating characteristic curves; Speed and voltage regulation, Selection of site for hydroelectric plant, Essential elements of hydroelectric power plant, Economics: cost structure, Initial and operation cost, environmental issues related to large hydro projects, Potential of hydro power in North East India.

Text Book

[1] Johnson G. L. (2006); *Wind Energy Systems* (Electronic Edition), Prentice Hall.

[2] Wagner H. and Mathur J. (2011); *Introduction to Hydro energy Systems: Basics, Technology and Operation*, Springer.

Reference Book

[1] Hau E. (2000); *Wind Turbines: Fundamentals, Technologies, Application and Economics*, Springer.

[2] Mathew S. (2006); *Wind Energy: Fundamentals, Resource Analysis and Economics*, Springer.

[3] Burton T. Sharpe D. Jenkins N. and Bossanyi E. (2001); *Wind Energy Handbook*, John Wiley.

[4] Nag P. K. (2008); *Power Plant Engineering*, Third Edition, Tata McGraw Hill. [5] Jiandong T. (et al.) (1997); *Mini Hydropower*, John Wiley.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 222	**Energy Efficiency in Process Utilities**	**0 1 2**	**5**	**3**

Unit I: **Energy Efficiency in Thermal Utilities**
Fuels and combustion, Boiler, Steam System, Furnaces, Insulation and refractories, FBC Boilers, Cogeneration, Waste and heat recovery

Unit II: **Energy Efficiency in Electrical Utilities**
Electrical system, Electric motors, Compressed air system, HVAC and refrigeration system, Fans and blowers, Pump and pumping system, Cooling tower, Lighting system, DG Set system, Energy efficient technologies in electrical systems

Unit III: **Energy performance assessment for equipment & utility systems**
Boilers, Furnaces, Cogeneration, turbines (gas, steam), Heat exchangers, Electric motors and variable speed drives, Fans and blowers, Water pumps, Compressors, HVAC systems Lighting systems, Financial analysis, Application of non-conventional & renewable energy sources, Waste minimization and resource conservation

Unit IV: Energy efficient sources and storage systems
Fuel cells: Classification and Types- advantages and Disadvantages, Conversion efficiency-types of electrodes, output and emf.
Batteries: thoery, defination, different types of battery arrangement- classification.
Hydrogen energy: hydrogen production, Electrolysis-thermo chemical methods, hydrogen storage, transportation and utilization.
Magneto Hydro Dynamic (MHD) Power Generation: Principles of MHD power generation, types.

Practicals:
Identification of energy efficient renewable sources, Study of Boilers, Study of Fuel Cells, Operation, repair & maintenance of Solar Photovoltaic systems for domestic and industrial use----PV cells, Cell manufacturing techniques, PV module and arrays, PV system, emerging technologies, measurement of current, voltage and power. Solar thermal devices, operation, repair and maintenance, solar cookers, advanced solar cooker, solar dryer, solar heater, solar heating and cooling, solar thermal electricity generation. Solar Electric System Installation, solar hot water system installation.

Text Book:
[1] Chakrabarti A, *Energy Engineering and Management*, PHI Learning Private Limited, 2011.
[2] Study material for Energy Managers and Auditors Examination: Paper I to IV, 2005.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 223	**Carbon Credit**	**0 1 3**	**7**	**4**

Theory

Energy and Climate Change: Global Consensus, GHGs emission and energy activities; evidence and predictions and impacts, Clean Energy Technologies, Energy economy, Risk and opportunities; Measures to reduce GHGs; Role of Renewable Energy. Climate Change Act, Kyoto Protocol and CDM, CDM activities in Industries; Emission benchmarks; Governments policies for mitigation and adaptation, National Action Plan on Climate change.

Carbon credit: Definition, concept and examples; Carbon credit: national policies *visàvis* international market scenario; Current efforts and future prospect/limitation of carbon trading mechanism. Commerce of Carbon Market, Environmental Transformation Fund; Technology Perspective: Strategies for technology innovation and transformation; future prospect/limitation of carbon trading mechanism.

Practical

Case study related to CR and CDM. Industrial visit and study of RE technology application in Industry

Text Book:

[1] Mathez E. A. (2009); *Climate Change: The Science of Global Warming and Our Energy Future*, First edition, Columbia University Press.
[2] Dessler A. (2011); *Introduction to Modern Climate Change*, Cambridge University Press.

Reference Book:

[1] Yamin F. (ed.) (2005); *Climate Change and Carbon Markets: A Handbook of Emissions Reduction Mechanisms*, Earthscan.
[2] Franchetti M. J. and Apul D. S. (2013); *Carbon Footprint Analysis: concepts, methods, implementation and case studies*, CRC Press.
[3] Clean Development Mechanism, UNFCC Website; http://cdm.unfccc.int/.
[4] Stern N. (2007); *The Economics of Climate Change. The Stern Review*. Cambridge University Press.
[5] Barrett S. (2007), *Why Cooperate? The Incentive to Supply Global Public Goods.* Oxford University Press.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 224	**Waste Recycling & Resources Recovery**	**1 0 4**	**9**	**5**

Unit I: Solid Waste:
Definition, types of Solid Waste, Waste minimization- reduce, reuse and recycle, Sources – agricultural & domestic, industrial etc. Impact of solid waste on health and environment, Handling, Treatment, Recovery and utilization of resources, solid waste management. Municipal solid waste management (MSWM)- goals and principles, policy, planning and framework for MSWM.

Unit II: Hazardous Waste Management:
Definition, concern about hazardous waste management, characteristics of hazardous waste, transportation and disposal of hazardous waste, control of hazardous waste, impact on health and environment.

Unit III: Biomedical/Radioactive Waste Management:
Biomedical- Definition, source, categories, collection, segregation, treatment and disposal of biomedical waste, Effect and management of biomedical waste.
Radioactive- Definition, Sources, low and high level radioactive wastes and their management.

Unit IV: e-waste management:
Definition, generation, collection, transportation and disposal.

Practical:
Identification of different types of wastes, Collection and analysis of solid wastes, identification of reusable and recyclable waste, identification of hazardous waste, Study of biomedical and radioactive waste, study of e-waste and its management, Study of management of different waste.

Text book:
[1] Rhyner C.R, Schwartz L.J, Wenger, R.B, Kohrell M.R, *Waste Management and Resource Recovery*, Taylor & Francis Group, 1995
[2] Singh J and Ramanathan A.L, *Solid Waste Management*, I.k. International Publishing House Pvt. Ltd., 2009.

Reference Book:
[1] Bhatt M.S. and Illiyan A., *Solid Waste Management: An Indian Perspective*, Synergy Books India, 2012.
[2] Hieronymi K., Kahhat R. and Williams E., *E-Waste Management: From Waste to Resource*, Routledge, 2012.

DSE 2 :: Elective

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 225	**Renewable Energy Grid Systems**	**2 1 0**	**3**	**3**

Power system- Introduction on electric grid, power supply, power quality and stability. Introduction to renewable energy grid integration, concept of mini/micro grids and smart grids: Wind, Solar, Biomass power generation, power generation features.

Load scheduling- Introduction to basic analysis and operation techniques on power electronic systems, power converters, Power conversion schemes between electric machines and the grid, Power systems control using power converters; Electronic conversion systems application to renewable energy generation systems, Basic schemes and functional advantages; Wind Power and Photovoltaic Power applications, Power control and management systems for grid integration, Synchronizing with the grid; Issues in integration of synchronous generator, induction generator and converter based sources; Network voltage management; Power quality management and Frequency management; Influence of PV/WECS on system transient response.

Electric Systems Modeling: Modeling and simulation of electric systems; Simulation tools, Simulation of grid connected/off grid renewable energy system (PV/WECS); Optimization and grid planning.

Text Book:

[1] Kersting W. H., *Distribution System Modeling and Analysis*, Second Edition, CRC Press, 2004 [2] Vittal V. and Ayyanar R., *Grid Integration and Dynamic Impact of Wind Energy*, Springer, 2012. [3] Gevorkian P., *Large-Scale Solar Power System Design: An Engineering Guide for Grid-Connected Solar Power Generation*, McGraw-Hill's, 2011.

Reference Book

[1] Bollen M. H. and Hassan F. (2011); *Integration of Distributed Generation in the Power System*, Wiley-IEEE Press.
[2] Keyhani A., *Design of Smart Power Grid Renewable Energy Systems*, Wiley–IEEE Press, 2011.
[3] Muhannad H. R. (2004); *Power Electronics: Circuits, Devices and Applications*, Pearson Prentice Hall Publisher

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 226	**Solar Thermal System and Applications**	**2 1 0**	**3**	**3**

Unit I:

Solar energy- Energy futures - Environmental philosophy - Solar insulation - Weather and climates - Heating/cooling needs - PV power production.

Unit II:

Thermal energy, Amount and distribution of thermal mass, Thermal energy storage, Re-radiation and release of heat at night or in cloudy weather-Thermal mass – heated/cooled by ground-coupling-Passive solar home – putting together the solar effects. Greenhouse passive heating - greenhouse design, the solar greenhouse-Vegetables - Starting early seed plants.

Unit III:

Domestic hot water (DHW), DHW tank storage capacity - configuration -Insulation -Temperature monitoring – Controls on DHW, Solar pond- operation, types, need.

Unit IV:

Space heating -Seasonal heat demand -Solar thermal collector heat utilization in winter Design of building envelope -Radiant floors -Living comfort-Geothermal heat pump -Thermal zone controls - Wood fireplace backup heat.

Unit V:

Space cooling – solar cooling, construction, operation, needs, temperature control. Solar Cooling building design- Living comfort.

Text Book:

1. Peuser F.A., Remmers K., and Schnauss M., *Solar Thermal Systems: Successful Planning and Construction*, Earthscan, 2002.
2. *Solar Thermal Systems Module Trainers Textbook*, Study materials in Renewable Energy Areas for ITI Students, MNRE, Govt. of India.

Reference Book:

1. Larson R. and West R.E., *Implementation of Solar Technology*, MIT Press, 2003.
2. Hull J.R., Nielsen C.E. and Golding P., *Salinity Gradient Solar Ponds*, CRC Press, 1989.
3. Duffie J. A. and Beckman W. A., *Solar Engineerin of Thermal Processes*, John Wiley & Sons, 3rd edition, 2006.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 227	**Solar PV Technology**	**2 1 0**	**3**	**3**

Unit – 1 Solar Power System

History of Solar PV -Solar Cell Physics -Solar Cell Electronics -Types of Solar Cells Technologies -Other Technologies -Concentrators -Solar Panel Arrays -Solar Power System Components **Solar Power Technologies** -Crystalline Solar Photovoltaic Module, Film Technologies -Solar Photovoltaic System.

Unit – 2 Solar Power System Design

Solar Power System Components and Materials -Solar Power System Configuration and Classifications -

Storage Battery Technologies-Solar Power System Wiring for Grid-Connected Solar Power systems Lightning Protection -Central Monitoring and Logging System Requirements -Ground-Mount Photovoltaic Module Installation and Support Hardware -Roof-Mount Installations -Electric Shock Hazard and Safety Considerations -Maintenance -Photovoltaic Design Guidelines

Insulation -Shading Analysis and Solar Energy Performance Multiplier-Site Evaluation -Solar Power Design

Unit – 3 Solar Power Generations

Designing a Typical Residential Solar Power System -Example of Typical Solar Power System Design and Installation Plans for a Single Residential Unit -Commercial Applications - Small-Scale Solar Power

Pumping Systems - Large-Capacity Solar Power Pumping Systems -Pump Operation Characteristics Semitropic Open Field Single-Axis Tracking System PV Array—Technical Specifications

Unit – 4 Energy Conservation - General Energy - Saving Measures - Power Factor Correction - Power Generation and Distribution Efficiency - Computerized Lighting Control - Electric Energy Compliance - Indoor Lighting Compliance - Outdoor Lighting and Signs – Performance Occupancy and Daylight Sensors – Web - Based Display Monitoring System - Solar Power Facts.

Text book:

1. Solanki C.S., *Solar Photovoltaic Technology and Systems,* PHI, 2013.
2. Solanki C.S, *Solar Phtovoltaics: Fundamentals,* Technologies and Applications, PHI, 2nd edition, 2011..

Reference Book:

1. Mukerjee A.K., *Photovoltaic Systems: Analysis and Design*, PHI, 2011.
2. *Basic Photovoltaic Principles and Methods*, SERI/SP-290-1448, 1982.

Skill (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
GC 311	**Communication Skill-II**	**1 1 2**	**6**	**4**

Speaking (Communicative English): Speak intelligibly using appropriate word stress and intonation patterns; adopt different strategies to convey ideas effectively according to purpose, topic and audience ; present oral reports or summaries and mane announcements clearly and confidently; express and argue a point of view clearly and effectively; take active part in group discussion, seminars showing ability to express agreement or disagreement, to summarize ideas, to elicit views of others, and to present own ideas; express and respond to personal; feelings, opinions and attitudes; frame questions as to elicit desired response, and respond appropriately to questions; participate in spontaneous spoken discourse in familiar social situations.

Oral communication

Information transfer activities : Pair and group-work involving transfer of information : reading a brochure/advertisement/notice and discussing these- finding a solution (arriving at a decision through speaking), Extempore speech (using clues, group discussions, etc.), Pair work (describing pictures, interpreting diagrams, finding information from different types of written materials and talking about them; formal seminar presentation; formal group discussion.

Text book:

1. Brazil, D. 1995. *A grammar of speech*. New York: Oxford University Press. ISBN: 019-437193-X.
2. McCarthy, M. 1999. *Spoken language and applied linguistics*. New York: Cambridge University Press. ISBN: 0521-59769-2.

Reference Book:

1. R, Sudarsanam *Understanding Technical English*, New Delhi: Sterling Publishers Pvt. Ltd., 1st edition, 1988.
3. Collins Cobuild, *English Grammar*, Harper Collins India, 6th edition, 1990.
4. *Oxford Advanced Learner's Dictionary (with CD-ROM*), Oxford University Press, 7th edition, 2005.

Skill (GEN)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
GC 314	**Computational Laboratory**	**2 0 3**	**8**	**5**

PRACTICAL : Practical based on Paper A and Paper B.
Paper A: Business Data Processing and Data Base Management

SECTION-A

- Introduction to Data Processing : Records and files : Data collection, preparation, verification, editing and checking.
- Business Files : Master and transaction files, file generations, backups and file recovery procedures.
- File sorting, searching, merging and matching. SECTION-B
- DBMS and its advantages; Data independence, data models; network model. DBTG proposal; data definition and manipulation languages, hierarchical and relational models, storage organisation for relations, relational algebra and calculus, relational query, languages query, processor and optimizer.

SECTION-C

- Design of a Database : Normalization theory for design of relational databases. Functional dependencies, normal forms, multivalued dependencies, decomposition, integrity, protection, security, concurrency, recovery, distributed data bases, available data base system.

SECTION-D

- Visual FoxPro : Getting started with FoxPro, data types, file handling commands, database control commands, indexing and sorting of a database file, searching and indexed file with FIND and SEEK. Summarizing database with count, sum, average, total. Creating and printing formatted reports.

Paper B: Web Programming

SECTION-A

- Internet : Evolution of Internet, Future of Internet, Services provided on the Internet, Internet Access Methods.
- World Wide Web : Evolution of www, Future of www, Fundamentals of web.
- Installing Netscape Communicator : Browising Internet using Netscape, Netscape Messenger.
- Hypertext Markup Language : Introduction to HTML, Building Vlocks of HTML, HTML Lists, HTML Links, Images in HTML.

SECTION-B

- Advanced HTML : HTML Tables, Frames, Layers, Forms, Editors.
- Cascading Style Sheets : Introduction to CSS, Limitation of HTML, CSS Positioning.
- Front Page : Installing Front Page, Front Page Editor, Create a Sample Website, Frames in Front Page, Front Page Components, Forms, Database pages.

SECTION-C

- Dynamic HTML : Moving elements and images, changing colours and hiding elements, moving between layers, mouse rollovers.
- Java Scripting : Features, tokens, data types, variables, operators, control structs, strings, arrays, functions, core language objects, client side objects, event handling, application related to client side from validation.

SECTION-D

- Fundamentals of Java Programming Language : Java vs. C++, bytecode, java virtual machine, constants, variables, data types, operators, expressions, control structures, defining class, creating objects, accessing class members, constructors, method overloading.

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Text Book:

1. B. W. Kerningham, *The Elements of Programming Style,* McGraw Hill, 2nd Edition, 1982.
2. B. W. Kerningham & D. Ritchie., *The C Programming Language,* Prentice Hall India, 2nd Edition, 2007.
3. E. Balaguruswamy. *Programming in C,* Tata McGraw Hill, 4th Edition, 2007.

Reference Book:

1. Kanetkar Y., *Let us C,* BPB, 8th Edition, 2006
2. Gotfreid, *Programming in C,* Tata McGraw Hill, Edition, 2008.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 311	**Renewable Energy Economics**	**2 0 1**	**4**	**3**

Energy System, Basics of renewable energy source and Energy transition. Energy economics: Basic concepts, Energy data and energy balance. Energy accounting framework; Economic theory of demand, production and cost market structure; National energy map of India

Concepts of economic attributes involving renewable energy, Net energy, the potential for energy efficiency from renewable energy, Calculation of unit cost of power generation from different sources with examples, energy technology diffusion modeling, Input and output optimization and simulation methods to energy planning and forecasting problems

Energy policies, economy and business fluctuation, oil import, energy conservation, rural energy economics, integrated energy planning

Conflict between energy consumption and environmental pollution, Economic approach to environmental protection and management, Energy-Environment interactions at different levels, energy efficiency, cost-benefit risk analysis; Project planning and implementation, Declining renewable energy costs, policies for renewable energy transition.

Practicals:

- understand the basics related to energy auditing;
- calculate relevant economic and environmental impacts due to energy saving;
- conduct a relative comprehensive energy auditing;
- design energy saving plans.

Text Book:

[1] Bhattacharyya S. C. (2011): *Energy Economics*, Springer

[2] Ferdinand E. B. (2000): *Energy Economics: A Modern Introduction*, First Edition, Kluwer

Reference Book:

[1] Kandpal T. C. and Garg H. P. (2003): *Financial Evaluation of Renewable Energy Technology*, Macmilan.

[2] Stoft S. (2000); *Power Systems Economics*, Willey-Inter Science

[3] Munasinghe M. and Meier P. (1993): *Energy Policy Analysis and Modeling*, Cambridge University Press.

Skill (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 312	**Energy Management & Auditing**	**0 1 2**	**4**	**3**

Energy scenario-Commercial and Non-Commercial Energy, Primary energy resources, energy production and consumption, energy needs of growing economy, long term energy scenario, pricing, energy and environment: Air pollution, climate change, energy security, conservation and its importance.

Basics of energy and its various forms- Electrical basic-AC&DC currents, power factor, load demand and management, Thermal basics- fuels, heat capacity, sensible and latent heat, temperature & pressure, evaporation, condensation, steam, moist air, humidity & heat transfer, Units and conversion

Energy management - definition, need, types, energy management approach, Energy performance, matching energy use to requirement, maximum system efficiency, optimizing the input energy requirements, energy audit instruments.

Material and energy balance- Energy system, Material and energy balance diagram.

Energy action planning- Energy management system, energy policy, organization, energy managerfunction, roles, responsibilities and accountability, motivation of employee, creating action plan. Financial management- Investment and criteria, financial analysis techniques, financing options, energy performance. Project management- definition and scope, technical design, financing, contracting, Implementation and performance monitoring, planning budget, different types of project planning techniques.

Text Book:

[1] Diwan P. and Yaqoot M., *Energy Management*, Pentagon Press, 2010.

[2] Sharma K.V and Venkataseshaiah P, *Energy Management and Conservation*, I K International Publishing House Pvt. Ltd; 2011.

Reference Book:

[1] Rajan G.G. *Energy Auditing of Process and Power Plants*, Productivity & Quality Publishing Pvt. Ltd. 2011.

[2] Study material for Energy Managers and Auditors Examination: Paper I to IV, 2005.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 313	**Instrumentation and Process Control**	**3 0 0**	**3**	**3**

Unit I: Instruments and Measuring Systems

Overview of Instruments and Measurement Systems: Principles of measurements and methods, elements of measurements system, errors in measurements, Classification of instruments, modes of operation, functions and applications, static and dynamic characteristics; Input output configurations of measuring instruments and measurement system.

Unit II: Transducers

Primary Sensing elements and transducers: Mechanical devices: types, pressure, flow rate sensing elements and their applications; Electric transducers: types and characteristics, resistive, capacitive, piezoelectric, optoelectronic transducers and their applications; Modern sensors.

Unit III: Control Systems

Introduction to Control Systems: Control systems: Feedback and non-feedback systems, reduction of parameter variations, block diagram of control system, regenerative feedback, Control systems and components

Unit IV: Digital Electronics and Microprocessors

Introduction to Digital Electronics Basics: Number systems, logic families, Boolean algebra, Combinational Logic designs, Multiplexers and demultiplexers, Registers

Signal conditioning: Operational amplifier types and characteristics, Application circuits inverter, adder, substacter, multiplier and divider, Analog /digital/analog conversion techniques

Data Acquisition Systems: Types of Instrumentation Systems, components, Applications, Single chanel and multichanel Analog to Digital and Digital to Analog converter (0804/0808/0809)

Microprocessors and Applications of Microcontrollers: Overview of microprocessor, microntroller (8951) architecture and Applications for monitoring and control of parameter and processes

Unit V: Non-electrical measuring instruments

Typical measuring and control instruments/devices for electric and non-electric quantities: Electronic voltmeter, Digital Power Analyser, Annemometer, Rotameter, Exhaust Gas analyzer, Automatic Bomb calorimeter, Junkers Calorimeter, Pyranometer, Pyrheliometer, Oxidation

Stabilty Apparatus, Maximum Demand Controller, Automatic light dimmer and on-off controller

Text Book

[1] Morris A. S. (1998); *Principles of Measurements and Instrumentation*, Prentice Hall of India. [2] Sawhney A. K. (2011); *A Course in Electrical and Electronics Measurements and Instrumentation*, Dhanpat Rai.

Reference Book

[1] Jain R. P. (1998); *Modern Digital Electronics*, McGraw Hill.

[2] Gaonkar R. (2012); *Microprocessor Architecture, Programming and Applications with 8085*, Penram International Publishing.

[3] Raman C. S. Sharma G. R. and Mani V. S. V. (1983); *Instrumentation Devices and systems*, Tata McGraw Hill.

[4] Kalsi H. S. (1995); *Electronic Instrumentation*, Tata McGraw Hill.

[5] Babu J. C. and Xavier S. E. (2004); *Principles of Control Systems*, S Chand and Co Ltd.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 314	**Power Electronics**	**3 0 0**	**3**	**3**

Unit -1 Power Devices -Introduction, SCR, DIAC and TRIAC – Construction and operation – SCR triggering methods and circuits – series and parallel connections of SCRs – TRIAC triggering circuits.Protection of Thyristors. Power diode, Power BJT, IGBT, MOSFET–Construction and operation, switching characteristics, applications, Comparison.

Unit – 2 Controlled rectifiers and Commutation of SCR -Controlled rectifiers – Principles of phase controlled converters – Half controlled-Semi controlled-full controlled-Dual converters, principles of cycloconverters, Single phase series converter. Introduction to commutation, Class A, B, C, D, E & F.

Unit - 3 Inverters and Static Switches -Single phase bridge inverter –Half bridge- Full Bridge Inverters. Voltage and frequency control of single phase inverters. Concept of PWM. Introduction – Single phase ac switches, Three phase ac switches – 3 phase reversing switches, ac switches for bus transfer – dc switches – solid state relays – AC voltage controller – Principles of ON/OFF control – principle of phase control.

Unit – 4 DC Choppers and Power supplies -Introduction to choppers - principles and control techniques–classification. Switching regulator – buck, boost regulator, buck boost regulator – cuk regulator – comparison between switching regulator and linear regulator. Half bridge and Full bridge converters. Bidirectional power supply – ac power supply–Inverters, UPS – types.

Unit – 5 Applications of Power Electronics Battery charging - Illumination control using TRIAC. DC motor drives –single phase drives –half wave, full wave, dual converter. Electric braking-industrial heating –Electrical welding-HVDC.

Text Book:

1. B R Gupta, V Singhal, *Power Electronics*, S K Kataria & Sons.
2. M.H. Rashid, *Power Electronics Circuit Devices and Application,*Pearson Education.

Reference Book:

1. Biswanath Paul, *Industrial Power Electronics and control*, PHI New Delhi.
2. P C Sen, *Power Electronics,* Tata McGraw Hill.

Elective (VOC)				
Course Code	**Course name**	**L T P**	**CH**	**Credit**
VR 315	**Electro Technology**	**3 0 0**	**3**	**3**

Unit I: D C Machines:

Basic Constructional features, E M F equation of D C generator, Elementary Idea of DC machine winding-winding pitch, Lap and Wave windings. Types of generators. Characteristics of DC generatorthe OCC and the load characteristics. The shunt generator-condition for voltage builds up. Load characteristics. Losses in a DC generator, Efficiency, Applications, Compound generators

Working principle of DC motor. Back EMF, Calculation of torque and power. Types of DC motors. Characteristics curves. Losses and Efficiency. Speed equation. Method of speed control. Method of starting. The 3 point, 4 point starter (calculations of the star resistors not required)

Unit II: Transformer:

Physical description of transformer. Elementary theory of the ideal transformer, EMF equation, Voltage and current transformation ratio. No load and load phasor diagrams. Transformer reactance and impedances. Equivalent resistance & reactance. Simplified equivalent circuit, open and short ckt tests. Losses and efficiency. Condition for maximum efficiency. All day efficiency. Voltage regulation. Star and delta connection in 3-ph transformer. The auto transformer, basic working principle.

Unit III: Induction motor:

Constructional features of 3-ph induction motor-principle of rotating magnetic field(mathematical treatment not required)Principle of operation of the 3-ph induction motor speed. Rotor emf, current and rotor cu loss, Torque, Starting torque .Maximum torque. Condition for maximum torque. Torque slip curves. Necessity of a starter. Methods of starting of squirrel cage and the slip-ring induction motors. Introduction to single phase induction motor. Nature of a field and torque produced in single phase induction motors (details of double revolving field not required).Types of motors-split phase, capacitors motors.

Unit IV: A.C. Synchronous machines:

Principle of operation of alternators. Constructional features of cylindrical generators and salient pole generators, EMF equation, Armature reaction. Synchronous impedance. Regulation of alternators, determination by synchronous impedance method.

Principle of operation of the synchronous motor, Synchronous motor on no load, Synchronous motor on load, Behaviour of the Synchronous motor with change of excitation-V curves. Starting methods of Synchronous Motor. Application of Synchronous motor.

Unit V: Measuring Instruments:

Dynamometer type wattmeter. Induction type wattmeter. Single phase induction type energy meter. Errors and compensations.

Text Book:

1. Theraja B.L and Theraja A.K., *A Textbook of Electrical Technology*, Volume I, II & III, S.Chand, 2005.
2. Kothari D.P., and Nagrath, I.J., Electrical Machines, Tata McGraw Hill, 2006.
3. Bhattacharya S.K., *Electrical Machines*, McGraw Hill Education, 2014.

Reference Book:

1. Rajput R.K., *Electrical Measurements and Measuring Instruments,* S.Chand, 2007.
2. Sawhney A.K., *Electrical Measurements And Measuring Instrumentations,* Dhanpat Rai & Co. 2013.

Skill (GEN)		
Course Code	**Course name**	**Credit**
VR 321	**Technical Communication and Reporting**	**3**

Industrial Training – Report writing – Seminars and Presentation to be conducted in the department.

Course Code	Course name	Credit
VR 322	**Mini Project/Industrial Training**	**5**

To be done by student during winter vacation.

Course Code	Course name	Credit
VR 323	**Case Study and Project**	**22**

Six months project work, special emphasis is given on the application of the knowledge and training for theoretical and experimental research in various areas of energy depending on student's interest for skill and knowledge development.

Controller of Examinations
Tezpur University
Tezpur, Assam