Course Code: **15EESC701**		Course Title: **Renewable Energy Systems**
L-T-P: **4-1-0**	Credits: **5**	Contact Hrs: **6 hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **50 hrs**		Exam Duration: **3 hrs**

1. **Thermo-chemical conversion :** Thermo-chemical conversion of biomass, biomass processing, briquetting, pelletisation, biomass stoves, biomass carbonization, pyrolysis of biomass, biomass gasification, gasifiers: [updraft(forced draft & Natural draft),downdraft (Open core, throat type & modular)], Gasifier stoves, gasifier thermal applications, gasifier engine applications: dual fuel and 100% gas mode operation, power generation systems: (decentralized grid interactive).
2. **Bio-chemical conversion** :.Aerobic, and anaerobic processes, activated sludge process, plug flow reactors, anaerobic fixed film reactor, UASB reactor, anaerobic fluidized bed reactor, estimation of methane yield, anaerobic digestion system for MSW, Vermi-composting, different designs of biogas plants for animal waste, Biogas engine applications.
3. **Liquid Bio fuels** : Liquid biofuels, non-edible oilseeds, oil extraction, preprocessing, transesterification, biodiesel, characterization of liquid fuels, production of syngas from biomass, production of methanol from syngas, production of ethanol from ligno-cellulosic biomass, Liquid bio-fuel applications.,
4. **Wind Energy**: Rotor aerodynamics, aerofoils, rotor design, wind turbine and its subsystems, Induction generator- characteristics, wind farms, power evacuation aspects, site selection, Integration with electric grid.
5. **Small Hydropower** : Classification of schemes, siting and economic considerations, System components: weir/intake, channel, desilting, forebay, spillway, penstock, turbine, generator, governor, control.
6. **Other Renewable Energy Technologies** : Geothermal, wave energy, tidal energy, ocean thermal energy
7. **Financial feasibility** of renewable energy technologies: case studies

Text / Reference Books

1. Donald Klass: Biomass for Renewable Energy, Fuels, and Chemicals, 1st Edn, Entech International Inc., USA, 1998
2. Paul Gipe, Wind energy Basics: A guide to Small and Micro-wind, Chelsea Green Publishing, 2008
3. Thomas Read, Agua Das, Handbook of Biomass Downdraft Gasifier Engine Systems, The Biomass Energy foundation Press, 1988
4. Klaus Von Mitzlaff, Engines for Biogas – Theory, Modification, Economic Operation, Division of the Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ) GmbH - 1988

Course Code: **15EESC703**		Course Title: **Energy Management**
L-T-P: **4-1-0**	Credits: **5**	Contact Hrs: **6 hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **50 hrs**		Exam Duration: **3 hrs**

1. **Energy Management**: Scope of energy management, necessary steps in energy management programme, general principles of energy management, qualities of energy manager, functions of energy manager, language of energy manager. Organizing, Initiating and managing an energy management program.
2. **Energy Auditing**: Elements and concepts, Types of energy audits, energy audit Instruments. Energy surveying and auditing, objectives, uses of energy, energy conservation schemes, energy index, cost index, pie charts, Sankey diagrams, load profiles (histograms), preliminary energy audit – detailed energy audit, questionnaire, energy audit instruments, Energy audit report writing.
3. **Economic Analysis**: Cash flows, Time value of money, Formulae relating present and future cash flows - single amount, uniform series. Payback period, Net present value, and Benefit-cost ratio, Internal-rate of return & Life cycle costs/benefits.
4. **Energy efficiency in Thermal utilities**: Oil-coal and gas Combustors, FBC boilers, Steam and condensate system, Furnaces, Cogeneration, Waste heat recovery equipments, Turbines, and Heat exchangers
5. **Insulation and Refractories**: types and application, economic insulation thickness, heat saving criteria, application of refractory, heat loss
6. **Utilization of Electric energy**: Heating methods: Resistance ovens, dielectric heating. Space heating in buildings, Illumination Engineering
7. **Energy Conservation in Electric Utility**: Motors, Fans and blowers, Pumps and Pumping System, Diesel Generating system, HVAC and Refrigeration System, Lighting System, Energy efficient technologies in electrical systems: power factor controllers, energy efficient motors, variable speed drives, energy efficient transformers, electronic ballast.

Text /.Reference Books

1. Turner W.C., Doty S., Energy Management Handbook, 8 ed., Wiley Inter Sc., 1982.
2. Taylor E. O., Utilization of Electric Energy, 1ed, Orient Longman. 2007
3. Reay D.A., Industrial Energy Conservation, 1ed., Pergamon Press. 1980.
4. Tripathy S.C.: Electric Energy Utilization and Conservation, TMG Delhi, 1991.
5. Indian Bureau of Energy Efficiency Manuals, BEE Publications, 2002

Course Code: **15EESP701**		Course Title: **Computational Lab**
L-T-P: **0-0-1**	Credits: **1**	Contact Hrs: **2 hrs/week**
CIE Marks: **80**	SEE Marks: **20**	Total Marks: **100**
Teaching Hrs: **---**		Exam Duration: **2hr**

(Exercises should be executed using relevant Computing and Programming tools)

1. zero, first and second order systems
2. Uncertainty analysis in the design of experiments-
3. Uncertainty analysis in use of manometers for pressure measurement
4. Uncertainty analysis in use of thermocouples for temperature measurements
5. Uncertainty analysis in use of pitot tube for flow velocity measurement
6. Use of the concept of Design of Experiments in simple flow related experiments

Course Code: **15EESP702**		Course Title: **Renewable Energy conversion Lab**
L-T-P: **0-0-1**	Credits: **1**	Contact Hrs: **2 hrs/week**
CIE Marks: **80**	SEE Marks: **20**	Total Marks: **100**
Teaching Hrs: **--**		Exam Duration: **---**

1. Solar radiation and wind speed measurements
2. Studies on Solar water heating system
3. Studies on solar Air heating System
4. Studies on Wind turbine for power generation and water lifting
5. Studies of Solar PV system
6. Studies on Biomass based Gasification and Bio-digester system
7. Use of HOMER for simulation of renewable energy systems

Course Code: **15EESC706**	Course Title: **Computational Fluid Dynamics**	
L-T-P: **4-1-0**	Credits: **5**	Contact Hrs: **6hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **50 hrs**		Exam Duration: **3 hrs**

1. **Computational Fluid Dynamics Solution Procedure**: CFD applications in Research and Design, CFD Problem set-up-Creation of geometry, Mesh generation, Specification of boundary conditions. CFD Solver- Initialization and Convergence monitoring. Post Processor-Plots, data reports and Animation
2. **Governing Equations for CFD**: Continuity Equation, Momentum Equation, Energy Equation**-** Physical Interpretation and comments. The additional equations for turbulent flow, Generic form of Governing equations, Physical Boundary conditions
3. **CFD Techniques**: Discretization of Governing Equations**-** Finite difference method, Finite volume method ,Converting governing equations into algebraic equations, Direct and Iterative solutions, Pressure- velocity coupling-SIMPLE scheme
4. **CFD Solution Analysis**: Consistency, Stability, Convergence, Accuracy and Efficiency of CFD solutions. Accelerating convergence, controlling solution errors, verification and Validation. Case studies related to fluid flow through channel and pipe bend.
5. **Practical Guidelines for CFD simulation and Analysis**: Grid generation- Guidelines on grid quality and grid design, Local refinement and solution adaption. Guidelines on Boundary conditions – Setting inlet, outlet and wall boundary conditions. Symmetric and Periodic Boundary conditions. Turbulence Modelling- Approaches, selection strategies, Case study: modeling of hydrofoil flows.
6. **Advanced Topics in CFD**: Advances in Numerical methods and Techniques- Moving grids, Multigrids, Parallel Computing and Immersed boundary methods. Advances in computational models- Direct numerical Simulation (DNS), Large Edddy Simulation (LES), RANS-LES, Lattice Boltzmann method, Monte-Carlo method, Particle methods.

Text /Reference Books

1. Jiyuan Tu, Guan Heng Yeoh, Chaoqun, Computational Fluid Dynamics, Butterworth- Heinemann, 1st Edn., 2008
2. Anderson D.A., Tannehill J.C., Platcher.R.H., Computational Fluid Mechanics and Heat Transfer; MGH, 2001.
3. Patankar Suhas V., Numerical Fluid flow and Heat transfer, Hemisphere Series on Computational Methods in Mechanics and Thermal Science,2nd Edn. 2000
4. Ferziger Joel H., Milovan Peric, Computational Methods for Fluid Dynamics, 3rd Edn., Springer- 2001
5. Anderson J D, Computational Fluid Dynamics Basics with Applications, MGH, 2nd Edn.,2001

Course Code: **15EHSC701**	Course Title: **Mathematical Thinking and Logical Reasoning**	
L-T-P:3-0-0	Credits: 3	Contact Hrs: 3 hrs / week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 180 min

No	Content	Hrs
1	**Unit 1: Arithmetical Reasoning and Analytical Thinking** **Chapter 1** – Arithmetical Reasoning 1.1 Number Systems and Speed Math 1.2 Factors and Multiples 1.3 Combinations 1.4 Probability 1.5 Percentages, Gain and Loss 1.6 Interest 1.7 Alligations and Averages 1.8 Man-Hour Calculations 1.9 Time, Speed and Distance **Chapter 2** – Analytical Thinking 2.1 Data Analysis 2.2 Data Interpretation 2.3 Data Sufficiency 2.4 Puzzle Tests	**34**
2	**Unit 2: Verbal and Non Verbal Logic** **Chapter 1 – Verbal Logic** 1.1 Verbal Analogy 1.2 Verbal Classification 1.3 Letter and Number Series 1.4 Decoding the Codes **Chapter 2 – Non – Verbal Logic** 2.1 Non – Verbal Analogy 2.2 Non – Verbal Classification 2.3 Pattern Completion 2.4 Pattern Comparison **Chapter 3 – Critical Reasoning** 3.1 Statements and Assumptions 3.2 Conclusive Reasoning	**06**

Reference Book:

1. R. S. Aggarwal, A Modern Approach to Verbal and Non – Verbal Reasoning – Sultan Chand and Sons, New Delhi.
2. Chopra, Verbal and Non – Verbal Reasoning –MacMillan India.
3. R. S. Aggarwal, Quantitative Aptitude –Sultan Chand and Sons, New Delhi.
4. Dr. Edward De Bono, Lateral Thinking –Penguin Books, New Delhi

Course Code: **15EESE706**		Course Title: **Research Methodology**
L-T-P: **4-0-0**	Credits: **3**	Contact Hrs: **4 hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **40 hrs**		Exam Duration: **3 hrs**

1. **Concepts and importance of Research Methodology:** Meaning of Research-Objectives-Types and Importance of Research-Research approaches, Significance of Research, Research methods versus methodology, Research and Scientific methods, Research Process, Criteria of good research
2. **Research Problem Definition**: What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration, and Conclusion.
3. **Research Design:** Meaning and Need, Concepts related to Research Design - Different Research Designs -Meaning–basic Principles of Experimental Designs, Important Experimental Designs
4. **Literature Review:** Clarity and focus to research problem, Improving Research methodology, Broadening knowledge base in research area, Enabling to contextualize findings, Review of Literature, Searching existing literature, Developing theoretical and conceptual framework, Writing about the literature reviewed
5. **Data Collection:** Introduction, Experiments and Surveys, Collection of Primary Data, Collection of secondary data, Selection of Appropriate Method for Data Collection, Case study method
6. **Data Preparation:** Data Preparation Process, Some Problems in Preparation process, Missing Values and Outliners, Types of Analysis, Statistics in research
7. **Testing of Hypothesis:** Basic Concepts of Hypothesis Testing, Test statistics and Critical region, Critical Value and Decision Rule, Hypothesis Testing- Procedure, Testing of Mean, Proportions, Variance, Difference of two Means, Difference of two Proportions, Difference of two variances, Limitations of the Tests of Hypotheses
8. **Chi-Square Tests:** test of Difference of more than two Proportions, test of Independence of Attributes, Test of Goodness of Fit, and Cautions in Using Chi-Square tests
9. **Interpretation and Writing Research Report:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions

Text/ Reference Books

1. Kothari C. R., Garg Gaurav, Research Methodology – Methods & Techniques, 3rd Edn, New Age International Pvt. Ltd, 2014
2. Ranjit Kumar, Research Methodology, , Sage Publications, 3rd Edn., 2011

Course Code: **15EESP704**		Course Title: **CFD Lab**
L-T-P: **0-0-1**	Credits: **1**	Contact Hrs: **2 hrs/week**
ISA Marks: **80**	ESA Marks: **20**	Total Marks: **100**
Teaching Hrs: **---**		Exam Duration: **---**

1. Illustration on mathematical behavior of PDEs through simple programme
2. Implicit and Explicit Solution for 1-D steady state heat conduction
3. Solution to transient heat conduction problem in 1D and 2D
4. Solution convective heat transfer problem on flow over flat surfaces
5. Solution of fluid flow in conduits like circular pipe and square ducts
6. Use of Open source CFD codes for simple heat flow problems

Books and References:

http://www.featflow.de
http://www.ansys.com
http://www.fluent.com

Course Code: **15EESC801**		Course Title: **Energy Systems Modeling & Analysis**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hrs: 4 hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **50 hrs**		Exam Duration: **3 hrs**

1. **Designing a Workable System**: Workable and optimum systems, Steps in arriving at a workable system, Creativity in concept selection, Workable Vs Optimum system, Designing of a food freezing plant.

2. **Equation-Fitting**: Mathematical modeling, Polynomial representation, Functions of two variables, Exponential forms, Best fit Method of least squares

3. **Modeling of Thermal Equipment**: Counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power

4. **System Simulation**: Classes of simulation, Information flow diagrams, Sequential and simultaneous calculations, Successive substitution, Newton-Raphson method

5. **Optimization**: Mathematical representation of optimization problems, A water chilling system, Optimization procedure, Setting up the mathematical statement of the optimization problem

6. **Lagrange Multipliers**: The Lagrange multiplier equations, unconstrained optimization, Constrained optimization, Sensitivity coefficients

7. **Search Methods**: Single variable – Exhaustive, Dichotomous and Fibonacci, Multivariable unconstrained - Lattice, Univariable and Steepest ascent

8. **Dynamic Programming**: Characteristic of the Dynamic programming solution, Apparently constrained problem, Application of Dynamic programming to energy system problems.

9.**Geometric Programming**:One independent variable unconstrained, Multivariable and Constrained optimization with zero degree of difficulty

10. **Linear Programming**: Simplex method, Big-M method, Application of LP to thermal systems

Text Books

1. W.F.Stoecker, Design of Thermal Systems, 3 ed., MGH,1989

Reference Books:

1.Hodge B.K., Analysis and Design of Thermal Systems, 1ed.,PHI, 1990.

2. Nagrath I.J., Gopal M., Systems Modelling and Analysis, 1 ed., TMGH., 2001

3. Wilde D.J., Globally Optimal Design, 1ed.,Wiley- Interscience, 1985

Course Code: **15EESE802**		Course Title: **Sustainable Building Design**
L-T-P-S: **4-0-0-0**	Credits: **4**	Contact Hrs: **4 hrs/week**
CIE Marks: **50**	SEE Marks: **50**	Total Marks: **100**
Teaching Hrs: **40**		Exam Duration: **3 hrs**

1.	**Introduction: Sustainability and Building Design**.
	Site planning: Site assessment, Site selection, Site analysis**,** site development and layout, sustainable urban drainage systems, flow attenuation
2.	**Efficient water management and waste water treatment techniques** Climate change and water conservation, the need for conservation, basic steps for reducing water consumption, Water conservation in landscape irrigation, Measures for reuse and conservation.
3.	**Solid waste management:** Introduction, guidelines for waste minimisation, Segregation of wastes, Resources recovery or recycling, Processing of waste.
4.	**Passive solar design:** Introduction, Thermal comfort, building physics, building design, building form, orientation, building components, Advanced soalr passive techniques, passive solar heating, passive cooling strategies, Day lighting, Factors for the design of day lighting, factors affecting daylight factor distribution. Innovative day lighting systems, Hybrid day lighting system.
5.	**Building technologies:** Traditional efficient building techniques, walling systems. Traditional stone masonry, Roofing systems, Doors and windows, High-rise masonry, curtain walls, pre-fabrication,
6.	**Energy systems:** units of lighting, lighting equipment, system design approach for energy-efficient lighting, Additional parameters for design approach for lighting, Approach for an energy efficient lighting system by sector, Energy conservation opportunities in existing lighting systems,
7.	**Building Envelop**: Domestic appliances, Non-domestic appliances, Heating ventilation and air conditioning systems, Use of renewable energy.

Text Books

1. Sustainable building Design manual volume-2, sustainable building design practices, TERI, New Delhi, 2004.

References:

1. S.P. Sukhatme, Nayak J.K.,Solar Energy:Principles of Thermal Collection and Storage, Tata-Mc-Graw Hill Education, 2008
2. Garg & Prakash, H. P. Garg,Solar Energy:Fundamentals and Applications, Tata-Mc-Graw Hill Education, 2000
3. G.N. Tiwari, Solar Energy:Fundamentals, Design, Modelling and Applications, Alpha Science International Limited, 2002

Course Code: **15EESW801**	Course Title: **Minor Project**	
L-T-P-S: **0-0-8-0**	Credits: **10**	Contact Hrs: **---**
CIE Marks: **100**	SEE Marks: **100**	Total Marks: **200**
Teaching Hrs: **---**		Exam Duration: **---**
Problem statement for the Minor Project is defined by the Guide. The Minor Project aims at developing professional competency and research aptitude by working in areas which otherwise are not covered in theory or laboratory sessions. The project work motivates the students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research The student will execute the project within three months duration during the 3rd semester		

Course Code: **15EESW802**	Course Title: **Major Project**	
L-T-P-S: **0-0-20-0**	Credits: **30**	Contact Hrs: **30**
CIE Marks: **100**	SEE Marks: **100**	Total Marks: **200**
Teaching Hrs: **40 Hrs**		Exam Duration: **3 Hrs**
The Major Project aims at developing professional competency and research aptitude by working in areas which otherwise are not covered in theory or laboratory sessions. The project work motivates the students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research Major Project is for a period of 8 months commencing from start of Industrial Training/Mini Project. The Project aims at developing professional competency and research aptitude by working in areas which otherwise are not covered in theory or laboratory sessions. The project work motivates the students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research		

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Course Code: 17EMEE701	**Course Title: Wind Energy Conversion Systems**	
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Introduction: Metrology of wind, Wind speed variation with height, Wind speed statistics. Wind Measurements Biological indicators, Rotational anemometers, other anemometers, Wind direction	10hrs
Basic concepts of Wind energy: Power output from an ideal turbine, Aerodynamics, Practical turbines, Transmission and generation efficiency	10hrs
Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.	10hrs
Wind Turbine Connected to the Electrical Network: Methods of generating synchronous power, AC circuits, The synchronous generator, Per unit calculations, The induction machine, Motor starting, Capacity credit, features of electrical network.	10hrs
Asynchronous Electric Generators: Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self excitation of the induction generators, Single phase operation the induction generator, Asynchronous Loads like Piston/ Centrifugal pumps, Paddle wheel heaters, Batteries	5hrs
Economics of Wind Systems: Capital costs, Economic concepts, Revenue requirements, Value of wind generated electricity, Hidden costs in Industrialized and developing nations	5hrs

Text Books

1. Gary L Johnson, Wind Energy Systems ,1ed., PHI, New Jersey, 2001
2. D.P.Kothari, I.G.Nagrath, Electrical Machines, 2ed.,TMGH, 2004

Reference Books

1 Rai G.D., Non-Conventional Energy Sources, 4 ed., Khanna Publications, 2002

Course Code: 17EMEC705	**Course Title: Energy Audit and Conservation**	
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

1. **Energy Management & Audit:** Definition, Energy audit- need, 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.	10hrs
2. **Energy Conservation:** Indian energy conservation act-2001, second law of thermodynamics, rules for efficient energy conservation of energy and materials, technologies for energy conservation (reducing demand using alternative supplies, load factor, balancing and energy storage), supply side options, demand side options, maximum demand controller, transmission and distribution side options	10hrs
3. **Energy Efficient Motors and Power factor:** Constructional details, factors affecting efficiency, losses distribution, soft starters, variable speed drives**.** Power Factor Causes and disadvantages of low power factor, methods to improve power factor, automatic power factor controllers	8hrs
4. **Energy efficient lighting** Terminology, cosine law of luminance, types of lamps, characteristics, design of illumination systems, good lighting practice, lighting control, steps for lighting energy conservation	7hrs
5. **Heat Recovery Systems:** Sources of waste heat, guidelines to identify waste heat, grading of waste heat, feasibility study of waste heat recovery, gas to gas heat recovery, rotary generators, heat pipes, gas to liquid heat recovery, waste heat boilers.	5hrs
6. **Cogeneration** Definition and need, basics of thermodynamic cycles, classification of cogeneration systems, steam turbine, gas turbine, typical heat to power ratio in various industries, operating strategies for cogeneration plant, typical cogeneration performance parameters, relative merits of cogeneration systems.	5hrs
7. **Compressed air network** Types of compressors, compressor selection, monitoring performance, specific power consumption, FAD test, capacity control and power consumption, compressed air distribution system, moisture separation**.**	5hrs

Text Books

1. WC Turner: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)
2. LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998).

Reference Book

1. George Polimeros: Energy Cogeneration Handbook, (Industrial Press, Inc., NY, 1981)
2. W Trinks, MH Mawhinney, RA Shannon, RJ Reed, JR Garvey: Industrial Furnaces, Sixth Edition, (John Wiley & Sons, 2003)

Course Code: 17EMEE706	**Course Title: Solar Photovoltaic System Design**	
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 4hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

1. **Introduction to PV Systems:** The PV Cell, The PV Module, The PV Array, Energy Storage, PV System Loads, PV System Availability, Associated System Electronic Components, Generators, Balance of System (BOS) ,Components. Present and Proposed PV Cells and Systems: Silicon PV Cells, Gallium Arsenide Cells, Copper Indium (Gallium) Diselenide Cells, Cadmium Telluride Cells, Emerging Technologies, New Developments in System Design	10hrs
2. **Grid-Connected Utility-Interactive PV Systems:** Applicable Codes and Standards, Design Considerations for Straight Grid-Connected PV Systems, Design of a System Based on Desired Annual System Performance, Design of a System Based on Available Roof Space, Design of a Micro-inverter-Based System, Design of a Nominal 21 kW System that Feeds a Three-Phase Distribution Panel, Design of a Nominal 250 kW System, System Performance Monitoring	10hrs
3. Mechanical Considerations: Important Properties of Materials, Establishing Mechanical System Requirements, Design and Installation Guidelines, Forces Acting on PV Arrays, Array Mounting System Design, Computing Mechanical Loads and Stresses, Stand-off, Roof Mount Examples.	10hrs
4. **Battery-Backup Grid-Connected PV Systems:** Battery-Backup Design Basics, A Single-Inverter 120 V Battery-Backup System Based on Standby Loads, A 120/240 V Battery-Backup System Based on Available Roof Space, An 18 kW Battery-Backup System Using Inverters in Tandem, AC-Coupled Battery-Backup Systems, Battery Connections.	10hrs
5. **Stand-Alone PV Systems:** The Simplest Configuration: Module and Fan, A PV-Powered Water-Pumping System, A PV-Powered Parking Lot Lighting System, A Cathodic Protection System, A Portable Highway Advisory Sign A Critical-Need Refrigeration System, A PV-Powered Mountain Cabin, A Hybrid-Powered, Off-Grid Residence, Summary of Design Procedures	5hrs
6. **Economic Considerations:** Life-Cycle Costing, Borrowing Money, Payback Analysis, Externalities and Photovoltaics**:** Externalities, Environmental Effects of Energy Sources, Externalities Associated with PV Systems	5hrs

Text Books

1. Roger Messenger, Amir Abtahi, Photovoltaic Systems Engineering, 3rd Edition, CRC Press, 2010,
2. Solanki C.S. Solar Photovoltaics : Fundamentals, Technologies and Applications, PHI., 2011

Reference Books

1. Matthew Buresch, Photovoltaic Energy Systems-Design and Installation, 1ed., MGH, 1983
2. Seippel R.G., Photovoltaics, 1 ed., Roston publication, 1986

Course Code:18EESP701	Course Title: **Energy System Lab**	
L-T-P: 0-0-2	Credits: 2	Contact Hrs: 4 hr/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching hrs: 24		Exam Duration: 02 hrs

Studies on : a. Operational experience on i) Pyranometer, ii) Sunshine recorder b. Measurement of temperature using Infrared Thermometers d. Measurement of illumination using Lux meter e. Exhaust gas analysis using gas analyzer **List of experiments** 1. Performance evaluation of a solar flat plate thermo-syphon water heating 2. Conversion efficiency of a solar flat plate forced solar water heating system 3. Conversion efficiency of a solar Concentrating water heating system 4. Determination of conversion efficiency of a solar air heating system 5. Study and analysis of a solar still / distillation plant 6. Performance estimation of photovoltaic water pumping system 7. Investigation on a solar dryer 8. Operational characteristics of P.V. Indoor lighting system 9. Determination of characteristics of a wind generator 10. Performance evaluation of solar cooker 11. P.V. System sizing exercise 12. Data acquisition system for monitoring of P.V system using LABVIEW s/w 13. Performance estimation of Solar fuel cell 14. Performance evaluation of vertical and horizontal axis wind turbine rotors.	24 hrs

Course Code:18EESP702	Course Title: **Industrial Instrumentation and Control Lab**	
L-T-P: 0-0-2	Credits: 2	Contact Hrs: 4 hr/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching hrs: 24		Exam Duration: 02 hrs

1. **Control technologies** Local manual, remote electrical, Local pneumatic, Remote analog/digital 2. **Basic electrical and math concepts**: Applications to instruments, Electrical principles and symbols, Series/parallel circuits 3. **Pressure instrumentation & measurements**: Pressure measurement devices, U-tube manometer, bourdon gauge, bellows gauge, piezoelectric 4. **Temperature instrumentation and measurements** • Measurement devices and techniques, Bimetallic temperature measurement, Filled capillary and bulb, thermocouple, resistance temperature detector (RTD), thermistors, thermowells, infrared 5. **Flow Instrumentation and Measurements:** Flow measurement methods, Factors influencing flow measurement, Flow measurement devices: orifice plates, venturi tube, flow nozzle, elbow taps, pitot tube, magnetic flow meter (Mag meter), vortex shedding meter, turbine meter, target flowmeter, ultrasonic, variable area rotameter, coriolis meter 6. **Level instrumentation and measurements:** Level measurement methods: sight glass, differential pressure level measurement, bubbler, displacer level sensor, float level sensors, capacitance, radiation-based, radar and ultrasonic level sensors 7. **Manipulating the process**: Final control element, Actuators, valve positioners, I/P, valves • Variable frequency drives 8. **Controllers:** Control modes: proportional, integral, derivative, Tuning feedback controllers ¼ decay, Zeigler-Nichols, damped oscillation, Ratio, cascade and feed-forward control 9. **Control systems**: Overview of PLCs, DCS and SCADA systems **Hands-on Exercises**: Sensor checkout, Hookup to calibration stands, Transmitter calibration check, Program/tune controller, Set up of differential pressure, temperature, and other process-simulation devices, Checking current output with Volt-Ohm Mille-ammeter (VOM) & tracing around loop, Simulate and source 4-20mA-DC signals	24 hrs

Course Code:18EESP703	Course Title: **Process Modeling and Simulation Lab**	
L-T-P: 0-0-2	Credits: 2	Contact Hrs: 4 hr/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching hrs: 24		Exam Duration: 02 hrs

MATLAB Analysis 1. Declination of earth, hour angle, day length, local apparent time. 2. Monthly average, hourly global and diffuse radiation on a horizontal surface and tilted Surfaces. 3. Power generation from a wind turbine, Variation of wind velocity and power with altitude. 4. Solution of ordinary differential eqations-4th order R K Method. 5. Solution of one-dimensional steady state heat conduction equation. 6. Solution of two-dimensional steady state PDE. 7. Solution of one-dimensional transient PDE. **Finite Element Analysis** 8. Two dimensional heat conduction. 9. One dimensional transient heat conduction. 10. Transient analysis of a casting process. **CFD Analysis** 11. Flow through a pipe bend. 12. Flow through a nozzle.	24 hrs

Course Code:18EESP704	Course Title: **IoT based Living Space Lab**	
L-T-P: 0-0-2	Credits: 2	Contact Hrs: 4 hr/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching hrs: 24		Exam Duration: 02 hrs

1. Introduction to IoT, Automation, Arduino, Raspberry Pi and IoT.	24 hrs
2. Introduction to Arduino programming and interfacing with peripherals and sensors Motor, Servo motor, LDR, PIR sensor, ultrasonic sensor, DHT 11, MQ2 smoke sensor, LCD and RC522 RFID	
3. Wireless communication with Arduino: GSM Module, Ethernet Shield. Raspberry Pi and Raspbian operating system: Installing operating system ,Starting Raspberry Pi desktop and using Linux commands	
4. Connecting to the network: Wired networking and Wireless networking, Setting up static IP for raspberry pi, Remote accessing of Raspberry Pi	
5. Python programming with Raspberry Pi: Introduction to Python, Python commands and Python scripting for programming GPIO	
6. Interfacing of Arduino with Raspberry Pi: Programming Arduino from Raspberry Pi using IDE Programming Arduino from Raspberry Pi using Python	
7. Raspberry Pi as web server: Installing Apache Server	
8. Connecting Arduino and Raspberry Pi to cloud service: Uploading Arduino sensor data to cloud. Connecting Raspberry Pi to cloud and interfacing sensors	
9. Conduction Of Living Space Lab Experiments Design of IoT based weather DAQ system IoT based temperature data monitoring and DAQ IoT based humidity data monitoring and DAQ IoT based solar insolation data monitoring and DAQ IoT based wind speed data monitoring and DAQ	
10. Design of Energy management system IoT based SPV - Solar generation data monitoring IoT based Wind generation data monitoring IoT based SPV – Wind hybrid generation data monitoring	

Course Code:**19EESC703**	Course Title: **Computational Methods in Engineering Analysis**	
L-T-P: 3-1-0	Credits: 4	Contact Hrs: 5
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

1.Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modelling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering.	06 hrs
2.Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton-Raphson method, Secant Method. Multiple roots, Simple fixed point iteration.	06hrs
3.Roots of polynomial- Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.	06 hrs
4.Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formulae, integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.	06 hrs
5.System of Linear Algebraic Equations and Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, iteration Methods.	06 hrs
6.Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.	05 hrs
7.Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engg.	05 hrs

Reference Books

1. Erwin Kreyszig , Advanced Engineering Mathematics, 10th Edition , Willely India, 2016.
2. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
3. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, TMGH, 4th Ed, 2002.
4. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.
5. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.
6. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.