1.1.2: Syllabus Revised Courses of PG Energy Systems Engineering

Course Code: 16EMEC707		**Course Title: Research Methodology**
L-T-P: 2-1-0	Credits: 3	Contact Hrs: 4hr/week
ISA Marks: 100	ESA Marks: --	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Research: Definition, Characteristics and Objectives; Types of Research, Research Methodology, Research Process, Literature Review, Review concepts and theories, Formulation of Hypothesis, Research design, Data collection, Processing and analysis of data collected, Interpretation of data, Computer and internet: Its role in research, Threats and Challenges to research, Writing a research paper, research project, Thesis, Research ethics, Citation methods and rules. Case studies	5hrs

Reference Books

1. Kothari C. R. "Research Methodology – Methods & Techniques", Vishwa Prakashan, A Division of New Age International Pvt. Ltd., 2008.
2. Ranjit Kumar, "Research Methodology – A step by step guide for Beginners", 3rd Edition, Pearson Edition, Singapore, 2011.
3. Dawson Catherine, "Practical Research Methods", UBS Publishers, New Delhi, 2002

Course Code: 17EMEC704	**Course Title: Instrumentation and Control in Energy 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

1. **Generalized configurations:** functional descriptions of measuring instruments. Measurement Errors for mechanical instruments. materials, radiant storage. materials, radiant storage	6hrs
2. **Transducer classification.** Generalized performance characteristics of instruments, Static and dynamic characteristics of transducers, Transient analysis of a control system	7hrs
3. Temperature Measurement: Use of bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry pyrometers.	7hrs
4. **Pressure Measurement:** Manometers, dynamic response of manometers, Bourden tube, Elastic pressure elements, electromechanical pressure transducers, Measurement of High Pressure and low pressure. Calibration of Pressure measuring equipment.	5hrs
5. **Flow Measurement:** Flow measurement methods, variable head flow meters for incompressible Fluids. Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters	5hrs
6. Air pollution and Measurement: Introduction, Gas sampling techniques, particulate sampling techniques, Sulphur dioxide measurements, Combustion Products Measurements Opacity and odour measurements	5hrs
7. **Miscellaneous measurements:** Measurement of liquid level, Measurement of Humidity moisture, measurement of O_2, CO_2 in flue gases. pH measurement	5hrs
8. **Instruments for monitoring electrical parameters,** Moving Iron/coil, Energy measurement, power factor meter	5hrs
9. Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and display, Data acquisition system	5hrs

Text Books

1. J.P.Holman: Experimental methods for engineers Sixth edition, McGraw-Hill ,Inc.1994
2. E.O Doebelin: Measurement Systems Applications & Design, McGraw Hill, 1990

Reference Books

1. Bechwith. Marangoni. Lienhard: Mechanical Measurements 5th edition. Addison-Wesley 2000
2. A.K. Ghosh: Instrumentation and Control. McGraw-Hill Inc.2003

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: 17EMEE702		**Course Title: Solar Thermal Systems 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	**Solar Radiation Analysis**: Solar constant, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces, Measurement of solar radiation	10hrs
2	**Heat Transfer for Solar Energy Utilization**: Introduction, modes of heat transfer, Reflectivity, Transmissivity, Transmitance-absorptance product, Heat exchangers	10hrs
3	**Liquid Flat Plate Collectors(FPC)**: Liquid FPC, conversion of solar radiation into heat General description of FPCs, losses and efficiency of FPC, Characteristics of FPC, Evaluation of Overall Loss Coefficient, Thermal Analysis of FPC and Useful heat gain, Mean plate temperature, Collector performance, Selective coating, Effect of dust and shading, material selection for FPC, Evacuated tube collectors	10hrs
4	**Flat Plate air heating collectors**: Introduction and types, performance and applications, heating and drying of Agricultural products, Psychrometric chart and its use, Design of Forced convection dryer	10hrs
5	**Performance testing of Solar Collectors**: Introduction, Governing performance equations, measuring instruments and methods, Testing procedures, Testing of Liquid flat plate solar collectors, Solar Air heaters. Overall performance of solar heating panels	05hrs
6	**Energy Storage**: Sensible heat and latent heat storage systems, thermo-chemical storage, shallow Solar pond, Collector and Storage heaters, Salinity gradient solar pond, Solar thermal storage systems	05hrs

Text Books

1. JA Duffie, WA Beckman: Solar Engineering of Thermal Processes, 3rd Edn. John Wiley
2. Sukhatme S P., Nayak J., Solar Energy: Principles of Thermal Collection & Storage, 3rd Edn, TMGH, 2008

Reference Books

1. Garg H.P., Prakash J., Solar Energy: Fundamentals and Applications TMH, 2015
2. Rai G. D., Solar Energy Utilization, 5 ed., Khanna publishers,2006

Course Code: 17EMEE704		**Course Title: Illumination Engineering**
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

Illumination Basics: Radiation, colour, eye & vision; different entities of illuminating systems; Light sources: daylight, incandescent, electric discharge, fluorescent, arc lamps and lasers; Luminaries, wiring, switching & control circuits	10hrs
Laws of illumination; illumination from point, line and surface sources. Photometry and spectrophotometry; photocells. Environment and glare. General illumination design.	10hrs
Interior lighting – Industrial, residential, office departmental stores, indoor stadium, theater and hospitals	10hrs
Exterior lighting- Flood, street, aviation and transport lighting, lighting for displays and signaling-neon signs, LED-LCD displays beacons and lighting for surveillance.	10hrs
Utility services for large building/office complex Layout of different meters and protection units. Different type of loads and their individual protections. Selection of cable/wire sizes; potential sources of fire hazards and precautions. Emergency supply – stand by & UPS. A specific design problem on this aspect	10hrs

Text Books

1 R. John Koshel, Illumination Engineering: Design with Nonimaging Optics, John Wiley & Sons, 2012
2 Jack L. Lindsey, Applied Illumination Engineering, The Fairmont Press, Inc., 1997

Reference Books

1. Kamalesh Roy,,Illuminating Engineering , Firewall Media,2006

Course Code: 17EMEW701		**Course Title: Mini Project-1**
L-T-P: 0-0-3	Credits: 3	Contact Hrs: 3hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 36		Exam Duration: 3 hrs

Theme: Renewable Energy	
The Mini-Project-1 envisages facilitating students for a real-time learning experience on working of renewable energy conversion and its performance characterization. The Project shall be executed as per the following methodology ✓ The review on Industry /scientific research status related to the product ✓ The study of product manuals related to renewable energy conversion devices available in market to capture the design-intent of the product. ✓ Apply fundamental concepts to work-out preliminary design calculation of the product envisaged through a customer survey and develop alternate design. ✓ Evidence use of computational tools to evolve product concept and its improvisation ✓ Fabrication of a working prototype/ scaled model /circuitry hardware ✓ Testing of the hypothesis through the fabricated device/ mathematical model The continuous assessment includes peer review and Faculty assessment at periodic intervals during the semester The Mini-project has to be documented by student in form of a Technical Report for submission during the End-semester Assessment.	36hrs

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: 17EMEC706		**Course Title: Demand-side Management**
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

Types of DSM measures : Energy reduction programmes : Load management programmes, Load growth and conservation programmes	5hrs
Economic Analysis and Financial Management: Investment needs, appraisal and criteria, sources of funds. Anatomy of investment – Initial investment, Return on Investment, Economic life, Basic income equations. Tax considerations: Depreciation, types and methods of depreciation, Income tax Considerations. Financial analysis: Simple pay back period, Return on investment (ROI), Net Present value (NPV), Internal Rate of Return (IRR), and Annualized cost, Time value of money, Cash flows, Discounting, Inflation Risk and sensitivity analysis, financing options. Pros and cons of the common methods of analysis	4hrs
Project Management: Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring. Implementation plan for top management, Planning budget, Procurement procedures, construction, Measurements and verification.	6hrs
Energy Monitoring, Targeting Review and Evaluation : Definition – Monitoring and targeting, elements of monitoring and targeting, data and information analysis, techniques energy consumption, production, cumulative sum of difference (CUSUM), Review and evaluation.	6hrs
Energy Policy : Need for Energy Policy for Industries, Formulation of Policy by any industrial Unit, Implementation in Industries, National & State level Policies	6hrs
Case Studies: Municipality Demand Side Management (Mu-DSM) scheme, Agriculture DSM, Small scale Enterprise DSM, Electrical power distribution DSM, Commercial Building DSM	3hrs

Text Books

1. W.R.Murphy, G.Mckay, Energy Management, Butterworths
2. C.B.Smith, Energy Management Principles, Pergamon Press).

Reference Books

1. CRC Handbook of Energy Efficiency – CRC Press

Course Code: 17EMEE705	**Course Title: Design of Heat transfer Equipments**	
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	**Heat Exchangers:** Classification and selection, Heat exchanger theory and fouling Shell and tube heat exchangers	10hrs
2	**Plate heat exchangers**: heat transfer and pressure drop, heat transfer prediction using Leveque analogy, design of plate heat exchangers	10hrs
3	**Design of shell and tube heat exchanger**: 1-2 parallel and Counter flow heat exchangers. Flow arrangements for increased heat recovery. Double pipe and Stirred Heat exchanger.	10hrs
4	**Heat exchanger for Gases**: Properties of gases, film coefficients, coolers for Air compressor and wet gases.	10hrs
5	**Equipments for boiling and Evaporation**: Classification of vapour generating Equipment, Analysis and design	10hrs

Text Books

1. Das Sarit K., Process Heat Transfer 1st Edn. Narosa 2006
2. Ozisik N. M., Heat transfer: Basic approach, 1ed., MGH, 2002
3. Holman J. P., Heat transfer 8 ed., MGH, 2006

Reference Book

1. Kays W.M, London A.L., Compact heat exchangers, 2nd Edn, MGH, 1955
2. Kern D.G., Process Heat Transfer, 1 ed., TMH, 2000
3. Schlunder, Heat exchanger Data hand book, Vol 2 & 3, 1983

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: 17EMEE707	**Course Title: Industrial Process Equipment 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

Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water	5hrs

treatment, Blow down, Energy conservation opportunities	
Steam System: Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings	4hrs
Furnaces: Classification, General fuel economy measures in furnaces, Excess air, Heat distribution, Temperature control, Draft control, Waste heat recovery.	6hrs
Electrical system: Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.	6hrs
Electric motors: Types, Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors	6hrs
Lighting System: Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues	3hrs
Fans and blowers: Types, Performance evaluation, Efficient system operation, Flow control strategies and energy conservation opportunities	5hrs
Energy Efficient Technologies in Electrical Systems: Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology	5hrs
Text Books 1. A.K.Shaha, Combustion Engineering and Fuel Technology, Oxford & IBH Publishing 2. Bureau of Energy Efficiency Publications **Reference Books/websites** 1. http://www.em-ea.org	

Course Code: 17EMEE708	**Course Title: Heating Ventilating and Air-conditioning**	
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. **Air-conditioning :**ASHARE nomenclature, psychometric processes on psychometric chart, coil by pass factor, estimation of cooling / heating load, plotting air conditioning processes for summer using ESHF concept, concept of comfort air conditioning, effective temperature concept	
2. **Introduction to HVAC:** Basic Air-Conditioning System , Zoned Air-Conditioning Systems , Choosing an Air-Conditioning System , System Choice Matrix Thermal Comfort: What is Thermal Comfort? Seven Factors Influencing Thermal Comfort ,Conditions for Comfort , Managing Under Less Than Ideal Conditions	10hrs
3. **Ventilation and Indoor Air Quality:** Air Pollutants and Contaminants ,Indoor Air Quality Effects on Health and Comfort, Controlling Indoor Air Quality, ASHRAE Standard, Ventilation for Acceptable Indoor Air Quality , Zoning Design, Controlling the Zone, ,Single Zone Air Handlers and Unitary Equipment, Examples of Buildings with Single-zone Package Air-Conditioning Units, Air-Handling Unit Components , Refrigeration Equipment , System Performance Requirements, Rooftop Units, Split Systems	10hrs
4. **Multiple Zone Air Systems:** Single-Duct, Zoned Reheat, Constant Volume Systems, Single-Duct, Variable Air Volume Systems , By-Pass Box Systems, Constant Volume Dual-Duct, All-Air Systems, Three-deck Multizone Systems , Dual-Duct, Variable Air Volume Systems, Dual Path Outside Air Systems	10hrs
5. **Hydronic Systems:** Natural Convection and Low Temperature Radiation Heating Systems, Panel Heating and Cooling , Fan Coils, Two Pipe Induction Systems, Water Source Heat Pumps, Hydronic System Architecture, Steam - Water Systems , Hot Water, Chilled Water ,Condenser Water	
6. **Energy Conservation Measures:** Energy Considerations for Buildings, ASHRAE/IESNA Standard, Heat Recovery , Air-Side and Water-Side Economizers, Evaporative Cooling, Control of Building Pressure	
7. **Refrigerants:** desirable properties, designation, azeotrops, secondary refrigerants, Ozone depletion, global warming, alternate refrigerant Applications of refrigeration systems: Industrial, comfort, food preservation and medical	10 hrs
8. **Special Applications:** Radiant Heating and Cooling Systems, Thermal Storage Systems , The Ground as Heat Source and Sink, Occupant Controlled Windows with HVAC , Room Air Distribution Systems ,Decoupled or Dual Path, and Dedicated Outdoor Air Systems	

Text Books

1. Robert McDowall, Fundamentals of HVAC Systems, Elsevier Publications First edition 2006
2. Richard C.Jordan & Gayle B.Priester, Refrigeration and Air Conditioning– PHI
3. Norman C.Harris, Modern Air Conditioning Practice by– McGraw-Hill International Edition

Reference Book

1. ASHARE Handbook: Fundamental, ASHARE publication, 2013
2. ASHARE Handbook: Standards, ASHARE publication, 2013

Course Code: 17EMEE709	**Course Title: Renewable Energy Grid Integration**	
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:** Introduction to renewable energy grid integration, concept of mini/micro grids, and smart grids	5hrs
2. **Synchronous Generator based Sources:** Review of synchronous generators, Introduction to power system stability problems: rotor angle stability, voltage stability and voltage collapse, classification of stability. Modeling of synchronous machines: dq transformations, synchronous machine representation in stability studies	8hrs
3. Induction Generator based sources: Introduction to induction machines: electrical characteristics, slip, speed-torque characteristics etc. Self excited induction generator, Constant speed Induction generators, Variable speed Induction generators, Doubly fed Induction generators.	12hrs
4. **Converter based Sources:** Introduction to power electronic devices, AC/DC converters, PWM, THD. Permanent magnet synchronous generator, solar PV systems, fuel cell, aqua-electrolizer	8hrs
5. **Grid Integration:** Issues in integration of synchronous generator based, induction generator based and converter based sources together. Network voltage management (discusses the issue of voltage levels). Power quality management (voltage dips, harmonics and flickers). Frequency management. Influence of WECs on system transient response System protection, Grid codes. ,Need of micro and smart grids	12hrs
6. Various Power System Studies: Various load forecasting techniques. Small signal stability, introduction to transient stability, voltage stability	5hrs
7. **Simulation Studies :** power system studies for grid connected/off grid PV system, grid connected/off grid WECS and small grid consisting of various renewable energy sources	5hrs

Text Books

1. Brendan Fox, Damian Flynn, Leslie Bryans, Wind Power Integration connection and system operational aspects, IET Power and Energy Series 50, 2007.
2. Marco H. Balderas (Edited): Renewable Energy Grid Integration- The Business of Solar Photo-voltaics , Nova Science Publishers, New York, 2009

Reference Books

1. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Michael Hughes, Wind Energy Generation Modeling and Control, Wiley and Sons, 2009
2. AJ Wood, BF Wollenberg, Power Generation, Operation and Control, John Wiley & Sons, New York, 1996

Course Code: 17EMEW702		**Course Title: Mini Project-2**
L-T-P: 0-0-3	Credits: 3	Contact Hrs: 3hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 36		Exam Duration: 3 hrs

Theme : Demand-side Management (DSM)	
The Mini-Project-2 envisages facilitating students for a real-time learning experience on working of Demand-side Management of Municipal supplies, Agriculture sector, Small Manufacturing Enterprises (SMEs), Commercial Building sector, Electrical distribution transformers.. The Project shall be executed as per the following methodology ✓ The review on Industry /scientific research status related to the product ✓ The study of current strategies adopted in demand-side management in different sectors in domestic and industrial sectors to capture the design-intent of the practice. ✓ Apply fundamental concepts to work-out preliminary design calculation of the strategy envisaged through a customer survey and develop alternate design. ✓ Evidence use of computational tools to study existing concept and its improvisation ✓ Fabrication of a working prototype/ scaled model /circuitry hardware ✓ Testing of the hypothesis through the fabricated device/ mathematical model The continuous assessment includes peer review and Faculty assessment at periodic intervals during the semester The Mini-project has to be documented by student in form of a Technical Report for submission during the End-semester Assessment.	36hrs

Course Code: 17EESC801	**Course Title: Economics and Planning of Energy Conversion**	
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

Case studies on evaluation of Economics and Financial feasibility of Energy conversion devices	
1. Indicators of Financial Performance, Incremental Analysis of Investment Projects Approaches of uncertainty in Financial Analysis ,Social Cost-benefit Analysis of Projects	10hrs
2. Case Studies to assess : Solar Distillation Plant	5hrs
3. Family size Bio-gas plant	5hrs
4. Box type Cooker.	5hrs
5. Improved Bio-mass cook-stove	5hrs
6. Energy Efficient Motors in Industries	5hrs
7. Solar Photovoltaic lanterns	5hrs
8. Power Generation from Rice-Husk	5hrs
9. Wind power gererator	5hrs

Text Books

1. Khandpal T.C., Garg H.P., Financial Evaluation of Renewable Energy Technologies, Mac-Millan India Ltd., 1st Edn, 2003
2. Sukhatme S.P., Nayak J.K., Solar Energy: Principles of Thermal Collection and Storage, TMGH, 2008

Reference Book

1. Tiwari G.N., Solar Energy:Fundamentals, Design, Modelling and Applications, Alpha Science International Limited, 2015

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:**18EESC802**		Course Title: **Energy Audit Practices**
L-T-P: 1-0-3	Credits: 4	Contact Hrs: 7hr/week
ISA Marks: 100	ESA Marks: --	Total Marks: 100
Teaching Hrs: 15		Exam Duration: 3 hrs

Electrical Distribution and Utilization Electrical Systems, Transformers loss reductions, parallel operations, T & D losses, P.F.improvements, Demand Side management (DSM), Load Management, Harmonics & its improvements, Energy efficient motors and Soft starters, Automatic power factor Controllers, Variable speed drivers, Electronic Lighting ballasts for Lighting, LED Lighting, Trends and Approaches. **Thermal Systems** Boilers- performance evaluation, Loss analysis, Advances in boiler technologies, FBC and PFBC boilers, Heat recovery Boilers, Furnaces, Refractories, Insulators, Steam utilization **Cogeneration** Integrated analysis of steam base co-gen system, Gas turbine combine cycle operation, IC engine base co-generation and tri-generation, extraction turbines and steam cycle of cogeneration. **System Audit of Mechanical Utilities** Pumps, Blowers, Compressors, Cooling Towers, HVAC & Psychometric, refrigerants new trends, COP, Capacity	15hrs
Field Studies **Energy Audit & Management in Industries** (Boilers, Steam System, Furnaces, Insulation and Refractories, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery.) **Electrical Energy audit and management** (pf improvement, Electric motors, Compressed air systems, Pumping systems, Fans and blowers, Cooling Towers, Industrial/Commercial Lighting system, Diesel based power Generation system) **Study of Energy Audit reports for various Industries and Organizations** **Case-studies / Report studies of Energy Audits** Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities	25 hrs
Reference Books: 1. W.R.Murphy, G.Mckay Energy Management, Butterworths, 2. C.B.Smith, Energy Management Principles, Pergamon Press 3. G.C.Dryden, Efficient Use of Energy: Butterworth Scientific 4. A.V.Desai, Energy Economics ,Wiley Eastern 5. D.A. Reay, Industrial Energy Conservation, Pergamon Press 6. W.C. Turner, Energy Management Handbook, John Wiley	

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.

Course Code:**19EESE703**	Course Title: **Cogeneration and Electric Vehicles**	
L-T-P: 3-1-0	Credits: 4	Contact Hrs: 5hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

1. Concept of Cogeneration Review on Thermodynamics of conventional power producing plants - Selecting cogeneration technologies.	8 hrs
2. Thermodynamics of Cogeneration Power Plants Performance criteria and effect of irreversibility - Comparative thermodynamic performance of cogeneration plants – Numerical examples – Calculations of typical heat to power ratios and performance parameters.	8 hrs
3. Design of CHP Design of Cogeneration plant for varying plant heat to power ratio – Fuel savings from installation of cogeneration plant - Applications of cogeneration technology to various process plants.	8 hrs
4. Electric Machines and their Controllers The 'Brushed' DC Electric Motor, DC Regulation and Voltage Conversion, Brushless Electric Motors Motor Cooling, Efficiency, Size and Mass, Electrical Machines for Hybrid Vehicles, Electric Vehicles: Drive-trains: Basic concept of electric traction - Introduction to various electric drive-train topologies - Power flow control in electric drive-train topologies – Fuel efficiency analysis.	8 hrs
5. Electric Vehicle Modelling Tractive Effort, Modelling Vehicle Acceleration, Modelling Electric Vehicle Range, Simulations, Design Considerations: Aerodynamic Considerations, Consideration of Rolling Resistance, Transmission Efficiency ,Consideration of Vehicle Mass, Electric Vehicle Chassis and Body Design, General Issues in Design, Software in the use of electric vehicle design	8 hrs

Reference books:

1. Sirchis, J., Combined Production of Heat and Power, Elsevier Applied Science, 1990.
2. Spiewak, S. A., Cogeneration, Fairmont Press Inc., 1991.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, John Wiley & Sons Ltd, 2003
4. Tariq Muneer, Mohan Kolhe, Aisling Doyle, Electric Vehicles: Prospects and Challenges, Elsevier 2017
5. Zoran Stevic, New Generation of Electric Vehicles, InTech Publishers , Croatia, 2012

Course Code:**19EESE708**		Course Title: **Hydrogen and Fuel Cells**
L-T-P: 3-0-1	Credits: 4	Contact Hrs: 5hr/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

1. **Hydrogen Energy Economy** Hydrogen Energy Economy – Conception, Present status and a vision – Applications of Hydrogen - Transport application-cars, light trucks, buses - Stationary and Portable-Electronic gadgets.	8 hrs
2. **Hydrogen And Production Techniques** HydrogenPhysical and chemical properties, salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation- Direct thermal or catalytic splitting of water.	8 hrs
3. **Hydrogen Storage & Transport** Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride – Chemical Storage – Comparisons - Transport of Hydrogen Pipelines, gaseous, liquid and compound materials.	8 hrs
4. **Fuel Cells** HistoryPrinciple - Working - Thermodynamics and kinetics of fuel cell process – Performance evaluation of fuel cell – Comparison on battery Vs fuel cell - Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits.	8 hrs
5. **Application Of Fuel Cell** Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells	8 hrs

Reference Books

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma (2005)
2. Bent Sorensen (Sorensen)Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005)
3. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
4. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press (2006)