Shri VaishnavVidyapeethVishwavidyalaya, Indore

Name of Program: M. Tech (Renewable Energy)

Session 2018-19

SUBJECT CODE	Category	SUBJECT NAME	TEACHING & EVALUATION SCHEME								
			THEORY			PRACTICAL		Th	T	P	CREDITS
			End Sem University Exam	Two Term Exam	Teachers Assessment *	End Sem University Exam	Teachers Assessment*				
MTMA101	MA	Advanced Mathematics	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;
Q/A – Quiz/Assignment/Attendance, MST Mid Sem Test.
*Teacher Assessment shall be based on following components: Quiz/Assignment/ Project/Participation in class (Given that no component shall be exceed 10 Marks)

Course Educational Objectives (CEOs):

1. To develop fundamentals of the Various Transforms and the techniques of finding the Analytical and the Numerical solutions of the PDE.
2. To develop modern Probability theorems with the applications and the Mathematical Modelling and the Solution of the various Random Processes.
3. To develop,The Concepts of the Fuzzy Set and various Operations with the Fuzzy Logic and the Reliability Engineering.

Course Outcomes (COs):

After the successful completion of this course students will be able to

1. Know the Analytical and the Numerical solutions of the PDE and the various Transforms used in the field of the Technology.
2. Apply the techniques used in the Modern Probability theorems.
3. Model and find the Solution of the various Random Processes.
4. Understand and apply the basics of the Fuzzy Set and various Operations with the Fuzzy Logic.
5. Deal with the problems of the Reliability Engineering.

Syllabus

UNIT I

Solution of Partial Differential Equation (PDE) by separation of variable method, numerical solution of PDE (Laplace, Poisson's, Parabola) using finite difference methods, Elementary properties of FT, DFT, WFT, Wavelet transform, Haar transform.

UNIT II

Probability, compound probability and discrete random variable. Binomial, Normal, Poisson's distribution. Sampling distribution, elementary concept of estimation and theory of hypothesis, recurred relations.

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UNIT III

Stochastic process, Markov process transition probability transition probability matrix, just and higher order Markov process, Markov chain. Queuing system, transient and steady state, traffic intensity, distribution queuing system, concepts of queuing models (M/M/1: Infinity/ Infinity/ FC FS), (M/M/1: N/ Infinity/ FC FS), (M/M/S: Infinity/ Infinity/ FC FS)

UNIT IV

Operations of fuzzy sets, fuzzy arithmetic & relations, fuzzy relation equations, fuzzy logics. MATLAB introduction, programming in MATLAB scripts, functions and their application.

UNIT V

Introduction and definition of reliability, derivation of reliability functions, Failure rate, Hazard rate, mean time t future & their relations, concepts of fault tolerant analysis, Elementary idea about decision theory and goal programming.

Reference Books:

1. Higher Engineering Mathematics by B.V. Ramana, Tata Mc Hill.
2. Advance Engineering Mathematics by Ervin Kreszig, Wiley Easten Edd.
3. Applied Numerical Methods with MATLAB by Steven C chapra, Tata Mc Graw Hill.
4. Introductory Methods of Numerical Analysis by S.S. Shastry,
5. Introduction of Numerical Analysis by Forberg
6. Numerical Solution of Differential Equation by M. K. Jain
7. Numerical Mathematical Analysis By James B. Scarborogh
8. Fourier Transforms by J. N. Sheddon
9. Fuzzy Logic in Engineering by T. J. Ross
10. Fuzzy Sets Theory & its Applications by H. J. Zimmersoms.

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			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE101		Applied Power Electronics & Drives	60	20	20	30	20	3	1	2	5

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
The course is designed to meet the objectives of:
1.To gather knowledge on power electronics equipment used for non-conventional energy systems.
2.To work on electrical machine drives in various non-conventional energy generation techniques.

Course Outcomes (COs): Upon completion of this course students will be able to:
1.Design of power electronics converters for various renewable energy systems.
2.Design and develop consumer products for the betterment of human kind.

UNIT I:
Energy Management Introduction: Power Electronics, requirements and application areas,Brief idea of Power Electronics application in areas like Power System, Motion Control, Heating, Automotive, Electric Welding, Renewable energy sources etc.,Concept of power processing. Signal Processing: Concept of Signal Processing and its requirements in PES
Analog signal processing circuits like precision rectifier, Log and Antilog Amplifier, Voltage multiplier, Divider, peak detector etc., Switched Capacitor circuits concept and realization of simple circuits,Analog computation, solution of simultaneous equations and differential equations through analogcircuits, ADC and DAC, V/F, F/V Converters, PLL,Timing Circuit, Multivibrators, Timer, PWM techniques

UNIT II:
Filters Circuits: Analog filter circuits, Filter response types, BP, HP, Notch, LP, Band Stop filter and basic circuits,Special filter circuits like state variable filter, biquad filter etc, Switched Capacitor filter circuit, Basic Power Modulator: (Basic power Diagram, working, advantages and disadvantages and classification only),Controlled & Uncontrolled rectifier Circuits, Inverter, Cyclo-converter DC to DC converter,

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UNIT III:
Power System Applications Introduction: Power system problems Concept and working of HVDC Transmission, Power factor correction, Static VAR Compensation,
Active power filter,Interconnection of renewable energy sources and Energy storage system to the utility grid. 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.

UNIT IV:
Power Supply and energy storage: Concept, working and types of SMPS and UPS Battery principle,Battery types, construction, applications, Charging methods and charging circuits for battery, Power Supply applications in various electronics systems, Industrial Applications: Induction Heating and dielectric heating, Electric Welding, Electroplating
Ultrasonic

UNIT V:
Consumer Electronics Applications: High Frequency Fluorescent lighting, LED lighting, fan regulator, Space Heating , Air Conditioning, Inducti
on Cooking, Motor Drives and Applications: Working principle of AC and DC Motor drives
• Automation in industry and motor drives applications like flow control, robot control, Electric Train, battery operated vehicles, conveyer belt, elevator, hoist etc.

Text Books:

1. Mc Pherson George, "Introduction to Electric Machines and transformers", John Wiley and Sons, 1980
2. Nasser Syed,A., "Electric Machine and Transformer", New York, Macmillan, 1984.
3. Sen., P.C., "Thyristor DC Drives", New York Wiley, 1991.
4. Fitzgerald, Kingsley C. and Umans,S.D.,"Electric Machinery",(5th Ed.,),McGraw-Hill 1992.
5. Clayton, A.E., "Performance and Design of Direct Current Machines",3rd Ed. Pitman 1961.
6. R. S. Ramshaw, "Power Electronics Semiconductor Switches", Champman & Hall, 1993.
7. N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics, Converter,
8. Application and Design", Third Edition, John Willey & Sons, 2004.
9. M. H. Rashid, "Power Electronics, circuits, Devices and Applications", Pearson, 2002, India.
10. K. Billings, "Switch Mode Power Supply Handbook", McGraw-Hill, 1999, Boston.
11. Pressman, "Switch Mode Power Supply Design", McGraw-Hill, 1999, New York.

Reference Books:

1. N. G. Hingorani and L. Gyugyi, "Understanding FACTS", IEEE Press, Delhi, 2001.

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2. B. K. Bose, "Power Electronics and Variable Frequency Drive", Standard Publishers Distributors, 2000.
3. Bin Wu, "High-Power Converters and AC Drives", IEEE Press, A John Wiley & Sons, Inc Publication, New York,2006.
4. G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, second edition, 1994, Avarua, Rarotonga, Cook Islands.
5. R. C. Duagan, M. F. Mcgranaghan and H. W. Beaty, "Electric Power System Quality", McGraw-Hill, 2001, 1221 Avenue of the Americas, New York.
6. 16.Vijay K. Sood, "HVDC and FACTS Controllers -Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Masachusetts, 2004.
7. J. Arrillaga, Y. H. Liu and N. R. Waston, "Flexible Power Transmission-The HVDC Options", John Wiley & Sons, Ltd, Chichester, UK, 2007

List of Experiments: Experiments can cover any of the above topics, following is a suggestive list:

1. Determination of complete torque speed characteristics of three phase induction machine in braking, motoring and generation regions and its calibration.
2. Understating the effect of rotor resistance on the load characteristics of a wound – rotor induction motor.
3. Determination of equivalent circuit parameters, prediction of performance. Verification from actual load rest. (b) Separation of losses of induction motor and estimation of efficiency.
4. Speed control of induction motor-Conventional, electronic. Solid state speed control using (i) V constant, (ii) V/f constant, (iii) slip –energy injection.
5. Load characteristics of induction generator working in (i) Grid connected mode (ii) Self Determination of equivalent circuit parameters of a single phase Induction motor. Prediction of torque-speed characteristics. Verification from load test.
6. Determination of torque step rate characteristics of a stepper motor. Determination of operating range.
7. Load characteristics of universal motor, operating and and ac supply comparison of performance.
8. Experimental determination of performance characteristics of two phase servo motor.
9. Load characteristics of hysteresis motor and shaded pole motor.
10. Characteristics of permanent magnet motor.
11. Characteristics of switched reluctance motor.

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			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE121		Optimization Techniques	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
To prepare the students to have knowledge of different types of optimization techniques and to identify tools of optimization in engineering applications.

Course Outcomes (COs): Upon completion of this course students will be able to:

1. Demonstrate constraint and unconstraint optimization.
2. Identify various optimization problems.
3. Solve various optimization problems.
4. Apply optimization in operation research.

Syllabus

UNIT I **[6 Hrs]**

Unconstrained Optimization: Introduction, Optimizing Single-Variable Functions, conditions for Local Minimum and Maximum, Optimizing Multi-Variable Functions

UNIT II **[8 Hrs]**

Constrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Direct Search Method, Lagrange Multipliers Method, Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary conditions, Kuhn –Tucker Sufficient Conditions.

UNIT III **[9 Hrs]**

Optimization: Quasi-Newton Methods and line search, least squares optimization, Gauss-Newton, Levenberg- Marquartd, Extensions of LP to Mixed Integer Linear Programming (MILP), Non-Liner Programming, The Newton Algorithm, Non-Linear Least Squares, Sequential Quadratics Programming (SQP), Constrained Optimization, SQP Implementation, Multi-Objective Optimization, Branch and Bound Approaches, Genetic Algorithms and Genetic Programming, Singular Based Optimization, On-Line Real-Time Optimization.

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UNIT IV **[9 Hrs]**

Optimization and Functions of a Complex Variable and Numerical Analysis: The Finite Difference Method for Poisson"s Equation in two Dimensions and for the Transient Heat Equation, Eulers Method, The Modified Euler Method and the Runga-Kutta Method for Ordinary Differential Equations, Gaussian Quardative Tranzoidal Rule and Simpson"s 1/3 and 3/8 Rules, the Newton Raphson in one and two Dimensions, Jacobi"s Iteration Method.

UNIT V **[9 Hrs]**

Optimization in Operation Research: Dynamic Programming, Transportation – Linear Optimization Simplex and Hitchcock Algorithms, Discrete Simulation, Integer Programming – Cutting Plane Methods, Separable Programming, Stochastic Programming, Goal Programming, Integer Linear Programming, Pure and Mixed Strategy in theory of Games, Transshipment Problems, Heuristic Methods.

Text Books:

1. S.S. Rao, Optimization: Theory and Applications, New Age International P. Ltd.

Reference Books:

1. S.S. Rao, Optimization: Theory and Applications, New Age International P. Ltd.
2. G.L. Nemhauser and L.A. Wolsey: Integer and Combinational Optimization, Wiley.
3. R.G. Parker and R.L. Rardin: Discrete Optimization, Academic Press.
4. Ravindren Philips and Solberg, Operation Research Principles and Practice (Second Edition) John Wiley & Sons.

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			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers				
MTRE122		Energy Storage System	60	20	20	-	-	3	1	-	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
Coverage of energy storage techniques involving electrochemical, mechanical and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design tradeoffs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage.

Course Outcomes (COs): Upon completion of this course students will be able to:

1. Compare and contrast methods of energy storage management in terms of cost, size, weight, reliability, efficiency and lifetimes.
2. Describe the energy storage need of the smart grid, both present and future.
3. Define the advantages and disadvantages of storage integration in various energy distribution systems, e.g. facility/home, substation, generation facility.
4. Summarize the impact of energy storage in an electric power system on power quality, power reliability and overall system efficiency.

Syllabus

UNIT I

Energy Storage Need of energy storage; Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage

UNIT II

Electrochemical Energy Storage Systems Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes.

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UNIT III

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

UNIT IV

Sensible Heat Storage SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage.

UNIT V

Latent Heat Thermal Energy Storage Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. Some Areas of Application of Energy Storage Food preservation; Waste heat recovery; Solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries.

Text Books

1. H.P.Garg et al, D Reidel (1885)"Solar Thermal Energy Storage", Publishing Co.
2. V Alexiades & A.D.Solomon(1993) "Mathematical Modeling of Melting and Freezing Proces" , Hemisphere Publishing Corporation,
3. WashingtonNarayan R, Viswanath B(1998), Chemical and Electro Chemical Energy System, Universities Press

Recommended Books

1. Ter-Gazarian(1994), "Energy Storage for Power Systems", Peter Peregrinus Ltd.London
2. B.Kilkis and S.Kakac (1989),"Energy Storage Systems",(Ed),KAP,London,1989

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Subject Code	Category	Subject Name	Teaching &Evaluation Scheme								
			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE123		Waste Management and Energy Generation Technologies	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
To prepare the students to have a basic knowledge of waste management and energy generation technologies. To prepare the students to have a basic knowledge of Waste minimization and recycling of Municipal Waste.

Course Outcomes (COs): Upon completion of this course students will be able to:

1. Understand the environmental monitoring System for Land Fill Gases.
2. Understand and analyze environmental effects due to Incineration.
3. Demonstrate Sources and Nature of Hazardous Waste.
4. Understand Industrial Applications of Gasifiers

UNIT I **[7 Hrs]**

Sources, Types, Compositions, Properties Physical, Chemical and Biological -Collection - Transfer Stations - Waste minimization and recycling of Municipal Waste.

UNIT II **[8 Hrs]**

Size Reduction - Aerobic Composting - Incineration for Medical /Pharmaceutical Waste - Environmental Impacts -Environmental Effects due to Incineration.

UNIT III **[9 Hrs]**

Land Fill Method - Types, Methods & Siting Consideration - Composition, Characteristics, generation, Control of Landfill Leachate & Gases –Environmental monitoring System for Land Fill Gases.

UNIT IV **[9 Hrs]**

Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste - Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure.

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UNIT V **[7 Hrs]**

Biochemical Conversion - Industrial , Agro Residues - Anaerobic Digestion -Biogas Production - Types of Biogas Plant-Thermo-chemical Conversion -Gasification - Types - Briquetting - Industrial Applications of Gasifiers -Environment Benefits.

Text Books:

1. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Printice Hall, 2000

Reference Books:

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985

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Subject Code	Category	Subject Name	Teaching &Evaluation Scheme								
			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE102		Solar Power Generation	60	20	20	30	20	3	1	2	5

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
To develop capability in the students to design solar thermal and solar photovoltaic power generating units in various modes for example: standalone, grid connected, hybridization.

Course Outcomes (COs): Upon completion of this course students will be able to:
1. Understand Solar Photo voltaic Systems.
2. Understand both theoretically and practically to use this subject for the application in solar power generation systems.

UNIT I
Solar radiation – Review. Models for radiation analysis and beam radiation calculations. Solar concentrators: Parabolic trough, parabolic dish: continuous type and Fresnel type Tracking mechanisms: single axis and double axis trackings

UNIT II
Solar thermal technologies: Solar Parabolic trough: design considerations, tracking and control systems, thermal design of receivers, Solar parabolic dish: design considerations, Sterling engine, Brayton cycle, tracking and control systems, Solar tower concepts: tower design, heliostat design, receiver types, tracking and control systems, Material and product/technology overview for the above technologies. Advanced collectors and solar concentrators, Selective coatings.

UNIT III
Emerging technologies: Linear Fresnel reflector, Solar chimney Solar pv power plants: Performance study, site selection and land requirement. Sizing and Reliability

UNIT IV
Solar PV power plants: Solar PV technologies overview - stationary and concentrated PV, inverter and control technologies, master slave inverter system design, standalone systems, grid connected systems, hybridization, synchronization and power evacuation, site selection

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and land requirements. Charge Conditioners, Interface Components, Balance of System Components.

UNIT V

Techno-economic analysis of solar thermal and solar PV power plants, Environmental considerations, green house gas calculations. Application of softwares: TRNSYS, RETScreen, Solar advisor, Design of one each solar thermal and solar PV power.

Text Books:

1. Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).
2. CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, (PHI Learning)
3. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition (John Wiley & Sons)
4. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)

Reference Books:

1. Duffie .J.A, Beckman W.A. "Solar Engineering of Thermal Processes, 3rd ed., Wiley, 2006.
2. De Vos .A, Thermodynamics of Solar Energy Conversion, Wiley-VCH, 2008.
3. Garg .H.P, Prakash .J, Solar Energy Fundamentals and Applications, Tata McGraw-Hill, 2005.
4. Kalogirou .S, Solar Energy Engineering, Processes and Systems, Elsevier, 2009.

List of Experiments: Experiments can cover any of the above topics, following is a suggestive list:

1. Determining the intensity of solar radiation.
2. Arrangement of Photovoltaic cells.
3. Setting up of the Photovoltaic panel with the help of the given settings to get the maximum exposure of the sunlight.
4. Measurement of V/I Characteristics of the mono-crystalline cells
5. Measurement of V/I Characteristics of Polycrystalline cells
6. Connecting of Photovoltaic cells in series and measuring their V/I Characteristics.
7. Connecting of Photovoltaic cells in Parallel and measuring their V/I Characteristics.
8. Connecting of Monocrystalline and polycrystalline cells in series and parallel and measuring their characteristics
9. Connecting a battery to the inverter and measuring the output using a meter
10. Connecting a battery to the inverter and observing the waveform using a oscilloscope
11. Doing exp no 8 & 9 with different loads.
12. Connecting a solar panel with inverter and measuring the output using meter.
13. Connecting a solar panel with inverter and observing the output using Oscilloscope

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			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE103		Energy Audit & Conservation	60	20	20	30	20	3	1	2	5

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs): Energy Management has been identified as a key instrument to reduce greenhouse gas emissions, besides increasing the cost competitiveness of the entity/ facility while enhancing the energy security of the nation. Policy makers and technology providers have been working towards the cause of energy efficiency and its overall management. This course is designed to educate students on the various dimensions of energy management cross the entire value chain

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

- Understand the importance of energy audit and its approach.
- Obtain knowledge about energy conservation policy, regulations and business practices
- Apply knowledge of Energy Conservation Opportunities in a range of contexts
- Develop innovative energy efficiency solutions and demand management strategies

Syllabus

UNIT-I

General Aspects

Energy Audit, types of energy audit; Energy Audit approach: optimizing the input energy requirement.

UNIT-II

Energy Audit Instruments.

Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy.

UNIT-III

Energy Management

Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers.

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UNIT-III

Introduction to Energy Conservation

Need for Energy Conservation Energy Sources, Supply & Demand Overview of Electrical and thermal Energy, Institutional Structure Energy Conservation Policies & Legislations National and International programs.

UNIT-IV

Energy conservation Act.

Energy Conservation: Basic concept, energy conservation in Household, transportation, Agricultural, service and Industrial sectors, Lighting, Heating Ventilation & Air conditioning.

UNIT-V

Energy Action Planning, Monitoring and Targeting. Tariffs and Power factor improvement in power system, Demand Side management concept, Energy Efficient Practices and Technologies.

Text Books:

1. Albert Thuman, William J. Younger, Terry Niehus *"Hand book of Energy Audits"*, The Fairmont Press, Inc., 2010
2. Kreith & Goswami *"Energy Management and Conservation Handbook"*, CRC Press, 06-Jul-2007
3. LC Witte,PS Schmidt and DR Brown:, *"Industrial Energy Management and Utilization"* Hemisphere PublishingCorporation,Washington,1998)

Experiments

1. Demonstration of various energy auditing instruments.
2. Measurement of efficiency of Hybrid Fuel cell .
3. Measurement of illumination using lux meter and its comparison with IS.
4. Calculate cooling load using temp. and humidity measurement
5. Measurement of energy consumption using energy meter.
6. Measurement of Noise level of environment.
7. Demonstration of weather quality parameters like temperature, humudity, intensity,
1. wind speed, etc
8. Emmissivity measurement.
9. Measurement of heat transfer in natural and forced convection.
10. Flash & Fire Point and Cloud & Pour Point of all type of fuels.

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			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE113		Grid connectivity and smart grid	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):
To provide students with a working knowledge of fundamentals, design, analysis, and development of Smart Grid, from the basic concepts of power systems to the inherent elements of computational intelligence, communication technology and decision support system.

Course Outcomes (COs): Upon completion of this course students will be able to:

1. Know what a function of smart grid is, what is the futuristic grid.
2. Understand the fundamental element of the smart grid.
3. Understand and analyze grid connectivity.

UNIT I **[6 Hrs]**

Introduction to grid connectivity of Renewable Energy systems, smart grid and emerging technologies, Operating principles and models of smart gird components, Key technologies for generation, networks, loads and their control capabilities;

UNIT II **[8 Hrs]**

Decision-making tools, Non conventional energy source models grid integration, Micro-turbine model and grid integration, Fuel cell model and grid integration, Energy storage and electric vehicle models and grid integration,

UNIT III **[10 Hrs]**

Distribution line models, Communication infrastructures for smart grid operation, Advanced metering infrastructure and advanced control methods, Economic dispatch, Demand response and demand management, Distribution feeder analysis, Continuous voltage and frequency control, Contingencies and their management, Unit commitment (selection of generators & loads to operate)

UNIT IV **[8 Hrs]**

Energy constraints: hydro, fuel management and maintenance scheduling, The operational challenges of distributed energy resources, Operation and control issues associated with

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intermittent generation, Electricity industry operation in a carbon constrained and 'smart grid' future

UNIT V **[8 Hrs]**

Impact of smart grid component integration on distribution network operation, Artificial Intelligence based approaches for estimation, scheduling, management and control of next generation smart grid.

Text Books:

1. James Momoh, Smart Grid Fundamentals of Design and Analysis, Wiley, 2012

Reference Books:

1. A. Keyhani, Smart Power Grid Renewable Energy Systems, Wiley 2011.
2. Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press.
3. Janaka Ekanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications ,Wiley.
4. Jean Claude Sabonnadiere, Nouredine Hadjsaid, Smart Grids, Wiley Blackwell.
5. Tony Flick and Justin Morehouse, Securing the Smart Grid, Elsevier Inc.

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Name of Program: M. Tech (Renewable Energy)

Session 2018-19

Subject Code	Category	Subject Name	Teaching &Evaluation Scheme								
			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE114		Converters for renewable energy system	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):

1. This give an introduction to the recent developments of power electronics from components, topology and control techniques.
2. This course drives on the application requirements of power electronics.
3. This is â higher level of subject that will help to work in demanding areas of power electronics in renewable energy systems

Course Outcomes (COs): At the end of the course student will be able to

1. Understand the principles of operation of advanced PWM converters.
2. Appraise various advanced converter topologies and the suitable control schemes.
3. Recognize recent developments in design aspects of renewable power conversion systems.

Syllabus

UNIT -I

Advanced Converters

Drawbacks of conventional converters & Inverters, Multi-pulse converters & Inverters, Improved power quality ac-dc converters such as single-phase buck, boost, buck-boost ac/dc converters, PWM (Pulse width modulated) based single- phase, three-phase VSC (Voltage source converters), Current Source Inverters.

UNIT-II

Multilevel Converters/ Inverters

Advance converter topologies for PEE - Interleaved converters, multilevel converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) multi pulse PWM current source converters, advanced control schemes, Capacitor unbalance

UNIT-III

PWM Schemes

Conventional PWM schemes & their performance, Multilevel PWM Schemes, Hybrid PWM schemes, Power converter topologies for solar and wind.

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UNIT-IV

Control of dc-dc converter, voltage mode control, current mode control, PID controller, sliding mode controller, Control of inverters.

UNIT-V

Case Studies

Literature- MLI Applications in Drives and power quality, Hybrid converters- Inverters-Closed Loop Renewable Energy conversion systems- PV power conversion using MLIs.

Text Books:

1. N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics Converter Application and Design*, ThirdEdition, John Willey & Sons, 2004.
2. M. H. Rashid, *Power Electronics, Circuits, Devices and Applications*, Pearson, 2002, India.

Reference Books:

1. K. Billings, *Switch Mode Power Supply Handbook*, McGraw-Hill, 1999, Boston.
2. Bin Wu, *High-Power Converters and AC Drives*, IEEE Press, A John Wiley & Sons, Inc Publication, New York,2006.
3. Relevant literature review for case studies and course applications.

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Name of Program: M. Tech (Renewable Energy)

Session 2018-19

Subject Code	Category	Subject Name	Teaching &Evaluation Scheme								
			Theory			Practical		L	T	P	Credits
			End Sem University Exam	Two Term Exam	Teachers Assessment*	End Sem University Exam	Teachers Assessment*				
MTRE115		Power Sources For Electric Vehicles	60	20	20	-	-	3	1	0	4

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit; Q/A Quiz/Assignment/Attendance, MST Mid Sem Test.

Course Educational Objectives (CEOs):

To prepare the students to have basic knowledge of different power sources for electric vehicle

To prepare the students to have knowledge of different fuel cells

Course Outcomes (COs): Upon completion of this course students will be able to:

1. Understand about different batteries
2. Conduct Different test on batteries.
3. Understand and analyze fuel cells.

UNIT I **[8 Hrs]**

The Electric Vehicle Debate, Primary Energy Sources and Alternative Fuels for Transportation, History of Electric Vehicles, Electrochemical Power Sources – Secondary

UNIT II **[10 Hrs]**

Batteries: Battery characterization, math modeling and designs, Battery sizing for various vehicle applications, Battery monitoring and charging control, Fuel cells: principles of operation, design, and modeling.

UNIT III **[10 Hrs]**

Batteries and Fuel Cells Sources- Aqueous Electrolyte Batteries –Lead Acid, Nickel – Iron, Nickel – Zinc, Metal – Air Zinc – Halogen Non Aqueous Electrolyte Batteries- High Temperature Batteries, Organo Electrolyte and Solid State Batteries

UNIT IV **[8 Hrs]**

Overview of Performances of Candidate Secondary Battery Systems-Fuel Cells – Acid Systems, Direct Methanol / Air Systems ,Alkaline Systems-Overview of Performances of candidate Fuel Cell Systems, Battery / Fuel cell / Internal

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UNIT V **[4 Hrs]**

Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles

Text Books:

1. B.D. McNicol and D.A.J. Rand, Power Sources for Electric Vehicles, Elsevier Publications.1998.
2. John Voelcker, Lithium Batteries for Hybrid Cars, IEEE Spectrum, 1990.

Reference Books:

1. David Linden and Thomas.B. Reddy,Hand Book of Batteries and Fuel cells, 3rd Edition, McGraw Hill Book Company, N.Y. 2002
2. Viswanathan, B. and Scibioh, Aulice M,Fuel Cells, Principles and Applications, Universities Press, 2006.
3. Nick Yost, The Essential Hybrid Car Handbook: A Buyer's Guide (Paperback), TheLyons Press, N.Y. 2006.

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