GURU KASHI UNIVERSITY

Master of Technology in Electrical Engineering

(Appendix-III)

Session: 2025-2026

Faculty of Engineering & Technology

Graduate Attributes of the Programme:

Type of Learning Outcomes	The Learning Outcomes Descriptors
Learning Outcomes that are specific to disciplinary/ interdisciplinary areas of learning	Graduates should be able to demonstrate the acquisition of:
	a comprehensive knowledge and coherent understanding of the chosen multidisciplinary areas of study in a broader context, their different learning areas, their linkages with related fields of study, and current and emerging developments associated with the chosen disciplinary/interdisciplinary areas of learning.
	Practical, professional, and procedural knowledge required for carrying out professional or highly skilled work/tasks related to the chosen field(s) of learning including skills in areas related to specialization in the chosen disciplinary/interdisciplinary area of learning in a broad context with practicalskills, involving contexts relating to the chosen field of learning.
Generic Learning Outcomes	***Complex problem-solving:*** The graduates should be able to demonstrate the capability to solve different kinds of problems in familiar and non-familiar contexts and apply the learning to real-life situations,
	Critical thinking: The graduates should be able to demonstrate the capability to apply analytic thought to a body of knowledge, including the analysis and evaluation of policies, and practices, as well as evidence, arguments, claims, beliefs, and the reliability and relevance of evidence,
	Creativity: The graduates should be able to demonstrate the ability to view a problem or a situation from multiple perspectives and think 'out of the box' and generate solutions to complex problems in unfamiliar contexts and adopt innovative, imaginative, lateral thinking, interpersonal skills and emotional intelligence.
	Communication Skills: The graduates should be able to demonstrate the skills that enable them to listen carefully, read texts and research papers analytically, and present complex information in a clear and concise manner to different groups/audiences

	Analytical reasoning/thinking: The graduates should be able to demonstrate the capability to evaluate the reliability and relevance of evidence and draw valid conclusions and support them with evidence and examples, and addressing opposing viewpoints.
	Research-related skills: The graduates should be able to demonstrate: • a keen sense of observation, inquiry, and capability for asking relevant/ appropriate questions and the ability to problematize, synthesize and articulate issues and design research proposals, • the ability to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships, • the appropriate use of statistical and other analytical tools and techniques and the ability to plan, execute and report the results of an experiment or investigation
	Coordinating/collaborating with others: The graduates should be able to demonstrate the ability to work effectively and respectfully with diverse teams and to facilitate cooperative or coordinated effort on the part of a group,
	Leadership readiness/qualities: The graduates should be able to demonstrate the capability for formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision.
	'Learning how to learn' skills: The graduates should be able to demonstrate the ability to acquire new knowledge and skills, including 'learning how to learn' skills, that are necessary for pursuing learning activities throughout life, through self-paced and self- directed learning aimed at personal development, meeting economic, social, and cultural objectives, and adapting to changing tradesand demands of the workplace, including adapting to the changes in work processes in the context of the

	fourth industrial revolution, through knowledge/ skill development/reskilling,
	Digital and technological skills: The graduates should be able to demonstrate the capability to use ICT in a variety of learning and work situations and use appropriate software for analysis of data and programming.
	Value inculcation: The graduates should be able to demonstrate the acquisition of knowledge and attitude that are required to adopt objective, unbiased, and truthful actions in all aspects of work, instill integrity and identify ethical issues related to work, and follow ethical practices.
	Autonomy, responsibility, and accountability: The graduates should be able to demonstrate the ability to: • work independently, identify appropriate resources required for a project, and manage a project to completion, • exercise responsibility and demonstrate accountability in applying knowledge and/or skills in work and/or learning contexts appropriate for the level of the qualification, including ensuring safety and security at workplaces.
	Environmental awareness and action: The graduates should be able to demonstrate the acquisition of and ability to apply the knowledge, skills, attitudes, and values required to take appropriate actions for mitigating the effects of environmental degradation, climate change, and pollution and effective waste management, and sustainable development and living.
	Community engagement and service: Graduates should be able to actively participate in services and activities that promote societal well-being.
	Empathy: Graduates should be able to understand and relate to the perspectives and emotions of others.

Programme Learning Outcomes: Master of Vocational (M. Voc) in Electrical Engineering is awarded to the students who have demonstrated the achievement of the outcomes located at level 7.

Element of the Descriptor	Programme Learning Outcomes of Master of Vocational (M. Voc) in Electrical Engineering
Knowledge and understanding	The graduates should be able to demonstrate the acquisition of advanced knowledge about a specialized field of Electrical Engineering with a critical understanding of the emerging developments and issues relating to the field, professional tasks relating to teaching, research and development.
General, technical and professional skills required to perform and accomplish tasks	The graduates should be able to demonstrate the acquisition of advanced cognitive and technical skills required for performing and accomplishing complex tasks related to the chosen fields of learning.
Application of knowledge and skills	The graduates should be able to demonstrate the ability to apply the acquired advanced theoretical and/or technical knowledge about a specialized field of enquiry or professional practice and a range of cognitive and practical skills to identify and analyze problems and issues, including real-life problems, associated with the chosen fields of learning.
Generic Learning Outcomes	The graduates should be able to demonstrate the ability to: • listen carefully, read texts, communicate, in a well-structured manner and present complex information in a clear and concise manner to different groups/audiences, • evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others • meet one's own learning needs relating to the chosen fields of learning, work/vocation, and an area of professional practice, • pursue self-paced and self-directed

	learning to upgrade knowledge and skills required to pursue higher level of education and research. • make judgement across a range of functions requiring the exercise of full responsibility and accountability for personal and/or group actions to generate solutions to specific problems associated with the chosen field of study, work, or professional practice.
Constitutional, humanistic, ethical, and moral values	The graduates should be able to demonstrate the willingness and ability to: • adopt objective and unbiased actions in all aspects of work related tothe chosen fields/subfields of study and professional practice and support relevant ethical and moral issues by formulating and presenting coherent arguments, participate in actions to address environmental protection and sustainable development issues,
Employability and job-ready skills, and entrepreneurship skills and capabilities/qualities and mindset	The graduates should be able to demonstrate the acquisition of knowledge and skills set required for: • adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive shift in employers' demands for skills, particularly with respect to t h e transition towards more technology-assisted work involvingthe creation of new forms of work and rapidly changing work andproduction processes. exercising full personal responsibility for the output of own work as well as for group/team outputs and for managing work that are complex and unpredictable requiring new strategic approaches.
Credit Requirement	44

Entry requirements	A 4 - year Bachelor's degree (B.E./B.Tech) for the 1-year/2-semester Master's of Vocational (M.Voc.) in Electrical Engineering programme.

Program Structure

SEMESTER: 1st									
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**	**In**	**Ex**	**Total Marks**
MEE1450	Advanced Power System Analysis	Core	3	0	0	3	30	70	100
MEE1451	Renewable Energy System	Core	4	0	0	4	30	70	100
MEE1500	Pulse Width Modulation for Power Electronics Converters	Core	4	0	0	4	30	70	100
MEE1501	Dynamics of Electrical Machines	Core	4	0	0	4	30	70	100
MEE1452	Advanced Power System Analysis Lab	Core	0	0	2	1	30	70	100
MEE1502	Seminar	Skill Based	0	0	4	2	30	70	100
Discipline Specific Elective-I (Any one of the following)									
MEE1503	Power Electronics for Renewable Energy systems	DSE1	4	0	0	4	30	70	100
MEE1504	Power System Operation and Control								
MEE1505	Battery Management Systems								
Total			**1**	**0**	**6**	**22**	**210**	**490**	**700**

SEMESTER: 2nd									
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MEE2550	Digital Protection of Power System	Core	4	0	0	4	30	70	100
MEE2551	AC and DC Drives	Core	4	0	0	4	30	70	100
MEE2552	Smart Grids	Core	4	0	0	4	30	70	100
MEE2553	Scada Systems and applications	Core	4	0	0	4	30	70	100
MEE2554	MATLAB Lab	EEC	0	0	4	2	30	70	100
Discipline Specific Elective-II (Any one of the following)									
MEE2555	Modern Optimization Techniques	DSE2	4	0	0	4	30	70	100
MEE2556	Restructured Power Systems								
MEE2557	Modern Control System								
Total			**20**	**0**	**4**	**22**	**180**	**420**	**600**

Programme Learning Outcomes: The Master's of Technology in Electrical Engineering M.Tech. EE) is awarded to students who have demonstrated the achievement ofthe outcomes located at level 7.

Master of Technology (M. Tech) in Electrical Engineering

Element of the Descriptor	Programme Learning Outcomes relating to Master of Technology (M. Tech) in Electrical Engineering
Knowledge and understanding	The graduates should be able to demonstrate the acquisition of: • advanced knowledge and understanding of the research principles, methods, and techniques applicable to the electrical engineering or professional practice, • procedural knowledge required for performing and accomplishing complex and specialized and professional tasks relating to teaching, and research and development.
General, technical and professional skills required to perform and accomplish tasks	The graduates should be able to demonstrate the acquisition of: • advanced cognitive and technical skills required for evaluating research findings and designing and conducting relevant research that contributes to the generation of new knowledge. • specialized cognitive and technical skills relating to a body of knowledge and practice to analyze and synthesize complex information and problems.
Application of knowledge and skills	The graduates should be able to demonstrate the ability to • apply the acquired advanced theoretical and technical knowledge about a specialized field and to identify and analyze problems and issues • apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems.

Generic Learning Outcomes	The graduates should be able to demonstrate the ability to: • listen, read analytically, and present complex information clearly to different audiences, including technical details and communicate research results and explanations in a structured manner, demonstrating a deep understanding of the chosen field. • Evaluate evidence, identify logical flaws, synthesize data from various sources, draw valid conclusions, and address opposing viewpoints. • Ability to analyze issues, design research proposals, and formulate relevant research questions, hypotheses, and solutions and Take responsibility for actions, demonstrate leadership, and make informed judgments to solve problems in the professional field. • Utilize quantitative and qualitative data to test hypotheses, make inferences, and predict cause-and-effect relationships and develop appropriate tools and methods for data collection and apply statistical and analytical techniques for research and evaluation. • Plan, conduct, and report research investigations effectively, demonstrating strong analytical skills and • Follow ethical guidelines in research practice and demonstrate responsibility in conducting research and use evidence to make informed decisions and adopt problem-solving approaches, addressing real-world challenges.
Constitutional, humanistic, ethical, and moral values	The graduates should be able to demonstrate the willingness and ability to: • adopt objective and unbiased actions in all aspects of work related tothe chosen fields/subfields of study and professional practice and follow ethical principles and practices in all aspects of research and development, including inducements for enrolling participants, avoiding unethical

	practices such as fabrication, falsification or misrepresentation of data or committing plagiarism. • participate in actions to address environmental protection and sustainable development issues
Employability and job-ready skills, and entrepreneurship skills and capabilities/qualities and mindset	The graduates should be able to demonstrate the acquisition of knowledge and skills required for adapting the future of work and responding to the demands of technological developments and innovations that drive shift in employers' demands for skills, particularly with respect to t h e transition towards more technology-assisted work involvingthe creation of new forms of work and rapidly changing work and production processes.
Credit Requirement	88
Entry requirements	A 4 - year Bachelor's degree (B.E./B.Tech) for the 2-year/4-semester Master's of Technology in Electrical Engineering programme (M. Tech).

SEMESTER: 3rd									
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MEE3600	Research Methodology	Core	4	0	0	4	30	70	100
MEE3601	Wind and Solar Energy	Core	4	0	0	4	30	70	100
MEE3602	Dissertation-I	Research Skill Based	0	0	0	12	30	70	100
MEE3603	Project	Skill Based	0	0	4	2	30	70	100
Total			**8**	**0**	**4**	**22**	**120**	**280**	**400**

SEMESTER: 4th									
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**	**Int.**	**Ext.**	**Total Marks**
MEE4650	Electric and Hybrid Vehicles	Core	4	0	0	4	30	70	100
MEE4651	Dissertation-II	Research Skill Based	0	0	0	12	30	70	100
MEE4652	Enterpreneurship	EEC	2	0	0	2	30	70	100
Discipline Elective-III (Any one of the following)									
MEE4653	Distributed Generation and Microgrid	DSE3	4	0	0	4	30	70	100
MEE4654	Smart Appliances and Internet of Things								
MEE4655	Energy Management and Auditing								
Total			**10**	**0**	**0**	**22**	**120**	**280**	**400**
Grand Total			**57**	**0**	**14**	**88**			

Semester: I

Course Title: ADVANCED POWER SYSTEM ANALYSIS

Course Code: MEE1450

L	T	P	Credits
3	0	0	3

Total Hours: 45

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Calculate voltage phasors at all buses, given the data using various methods of load flow
2. Calculate fault currents in each phase
3. Rank various contingencies according to their severity
4. Estimate the bus voltage phasors given various quantities viz. power flow, Voltages, taps, CB status.

Course Content

UNIT 1 **15 Hours**

Overview of Newton-Raphson, Gauss-Siedel, Fast Decoupled methods, convergence properties, sparsity techniques, is handling Q_{min} and Q_{max} violations in Jacobian matrix, inclusion of frequency effects, Automatic Voltage Regulation in load flow.

UNIT 2 **15 Hours**

Simultaneous faults, open conductor faults, generalized method of fault analysis. Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking.

UNIT 3 **10 Hours**

Power System Equivalents, Ward Method, and Radial, Equivalent and Independent (REI) equivalents for reduction of large power system models. Sources of errors in measurement, Virtual and Pseudo Measurements, Observability, Tracking state estimation, Weighted Least Square method, bad data correction.

UNIT 4 **5 Hours**

Voltage Stability**,** Voltage collapse, P-V curve, multiple power flow solution, continuation power flow, optimal load flow, voltage collapse proximity indices.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *J.J. Grainger and W.D. Stevenson, "Power system analysis", McGrawHill,2003*
- *A. R. Bergen and Vijay Vittal, "Power System Analysis", Pearson,2000*
- *L.P. Singh, "Advanced Power System Analysis and Dynamics", New Age International,2006*
- *G. L. Kusic, "Computer aided power system analysis" ,Prentice Hall India,1986*
- *A. J. Wood, B. F. Wollenbergand G. B. Sheblé, "Power generation, operation and control", Wiley, 2013*
- *P.M. Anderson, "Faulted power system analysis", IEEE Press ,1995*

E-Book and Online learning material:

- Debapriya Das, Indian Institute of Technology, Kaharagpur,
- https://swayam.gov.in/courses/4745-july-2018-power-system-analysis
- https://archive.nptel.ac.in/courses/108/105/108105067/
- https://archive.nptel.ac.in/courses/117/105/117105140/

Semester: I

Course Title: RENEWABLE ENERGY SYSTEM

Course Code: MEE1451

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Knowledge about renewable energy
2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System
4. Understand power quality issues of distributed generation.

Course Content

UNIT 1 **15 Hours**

Introduction: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE).

UNIT 2 **15 Hours**

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder.Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system.

UNIT 3 **15 Hours**

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and muliblade system. Vertical axis- Savonius and darrieus types. Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft).

UNIT 4 **15 Hours**

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC. **Green Energy**: Introduction, Fuel cells: Classification of fuel cells – H2; Operating principles, ZeroenergyConcepts.Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *R. Ranjan, D. P. Kothari, and K. C. Singal, "Renewable Energy Sources and Emerging Technologies", Prentice Hall of India,2011.*
- *M. H. Bollen and F. Hassan, "Integration of Distributed Generation in the Power System", Wiley –IEEE Press,2011.*
- *L.L. Lai and T.F. Chan, "Distributed Generation: Induction and Permanent Magnet Generators", Wiley- IEEE Press,2007.*
- *R. A. Messenger and J. Ventre, "Photovoltaic System Engineering",2010.*
- *J. F. Manwell, J.G. McGowan and A.L Rogers, "Wind energy explained: Theory, Design and Application", John Wiley and Sons,2010.*

E-Book and Online learning material:

- *Technical University of Denmark, https://www.coursera.org/learn/wind-energy*
- *P.Haridos, IIT Madras,https://swayam.gov.in/courses/4894-july-2018-non-conventionalenergy-resources*
- *A. Smets, Sustainable Energy: Design a Renewable Future, TU Delft &EDX*
- *A. Smets, Solar Energy, TU Delft &EDX*
- *A. Stegner, P.P. Drobinski, Wind resources for renewable energies, École Polytechnique & Courser*
- *https://onlinecourses.nptel.ac.in/noc22_ch27/preview*
- *https://onlinecourses.nptel.ac.in/noc21_ph33/preview*

Semester: I

Course Title: PULSE WIDTH MODULATION POWER ELECTRONICS CONVERTERS

Course Code: MEE1500

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. To understand Necessity and Importance of PWM techniques.
2. Implementation of PWM controllers.
3. Control CSI and VSI using PWM.
4. Compare performance of converter for different PWM techniques.

Course Content

UNIT 1 **13 Hours**

Introduction to Power Electronics Converters:

Modulation of One Inverter Phase Leg: Fundamental concepts of PWM, Evaluation of PWM schemes, Naturally sampled PWM, PWM analysis by duty cycle variation, Regular sampled PWM, Direct modulation.

Modulation of Single-phase Voltage Source Inverter: Topology of a single phase inverter, Three level modulation of a single phase inverter, Harmonic losses. Modulation of Three-phase Voltage Source Inverter: Topology of three phase inverter (VSI), Three phase modulation with sinusoidal references, harmonic losses, discontinues modulation**.**

UNIT 2 **17 Hours**

Zero Space Vector Placement Modulation Strategies: Space vector modulation, Harmonic losses for SVM, Placement of the Zero space vector, Discontinuous modulation (120,60,30 degree), Harmonic losses for discontinuous PWM. Modulation of Current Source Inverter: Three phase modulators as state machines, Naturally sampled CSI space vector modulator.

Over modulation of an Inverter: The over modulation region, naturally sampled and regularly sampled over modulation of one phase leg of an inverter, naturally sampled over modulation of single-phase and three-phase inverters.

UNIT 3 **15 Hours**

Programmed Modulation Strategies: optimized space vector modulation, harmonic elimination PWM, Performance Index for optimality, Optimum PWM, Minimum loss PWM.

Pulse Width Modulation for Multilevel Inverters: PWM of cascaded single phase Hbridges, over modulation of cascaded H bridges, PWM alternatives for diode-clamped multilevel inverters, three level naturally sampled PD PWM, over modulation of three level inverters, five level PWM for diode clamped inverters. PWM of higher level inverters.

UNIT 4 **15 Hours**

Implementation of Modulation Controller: Overview of a power electronic conversion system, Elements of a PWM converter system, Hardware implementation of the PWM process, PWM software implementation.

Continuing Developments in Modulation: Random PWM, PWM Rectifier with Voltage unbalance, Effect of minimum pulse width, PWM Dead-Time compensation.

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *D. Grahame Holmes, Thomas A. Lipo, 'Pulse width modulation of Power Converter: Principles and Practice', John Wiley & Sons, 2003.*
- *Bin Vew, 'High Power Converter', Wiley Publication.*
- *Marian K. Kazimicrczuk, 'Pulse Width modulated dc-dc Power Converter', Wiley Publication.*

Semester: I

Course Title: DYNAMICS OF ELECTRICAL MACHINES

Course Code: MEE1501

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Formulation of electro dynamic equations of all electric machines
2. Analyze the performance characteristics using Park's transformation
3. Knowledge of transformations for the dynamic analysis of machines
4. Knowledge of determination of stability of the machines under small signal and transient conditions

Course Content

UNIT 1 **15 Hours**

Introduction: Stability, Primitive Four Winding Commutator Machine, Commutator Primitive Machine, Complete Voltage Equation of Primitive Four Winding Commutator Machine

UNIT 2 **13 Hours**

Torque Equations: Torque Equation Analysis of Simple DC Machines using the Primitive Machine Equations, The Three Phase Induction Motor, Transformed Equations, and Different Reference Frames for Induction Motor Analysis Transfer Function Formulation.

UNIT 3 **15 Hours**

Three Phase Synchronous Machine: Three Phase Salient Pole Synchronous Machine, Parks Transformation, Steady State Analysis Dynamic analysis: Large Signal Transient, Small Oscillation Equations in State Variable form, Dynamical Analysis of Interconnected Machines.

UNIT 4 **15 Hours**

Transient Analysis: Large Signal Transient Analysis using Transformed Equations, DC Generator /DC Motor System Alternator /Synchronous Motor System.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *D.P. Sengupta and J.B. Lynn," Electrical Machine Dynamics", The Macmillan Press Ltd.1980*
- *R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education.,2001*
- *P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill BookCompany,1987*
- *I. Boldia and S.A. Nasar, "Electrical Machine Dynamics", The Macmillan Press Ltd. 1992 5. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London.1967*

E-Book and Online learning material:

1.http://www.darshan.ac.in/Upload/DIET/Documents/EE/CED_Ch_2_Dynamics_of_Electrical_Drives_v1_0 3042018_095922AM.pdf

Semester: I

Course Title: ADVANCED POWER SYSTEM ANALYSIS LAB

Course Code: MEE1452

L	T	P	Credits
0	0	4	2

Total Hours: 30

List of experiments:

1. Simulation of IGBT Inverters.
2. Simulation of Thyristor Converters.
3. Transient Stability Studies.
4. Short Circuit Studies.
5. Load Flow and optimal load flow Studies.
6. Gauss-Seidel load flow analysis using Soft Tools
7. Newton-Raphson load flow analysis using Soft Tools
8. Simulation of automatic generation control.
9. YBus formation using Soft Tools.
10. Z_{Bus} formation using Soft Tools.

Semester: I

Course Title: SEMINAR

Course Code: MEE1502

L	T	P	Credits
0	0	4	2

Total Hours: 30

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Presentation Skills will improve.
2. Discussion Skills among the learners will be inculcated.
3. Listening Skills will demonstrate that they have paid close attention.
4. Argumentative Skills and Critical Thinking.

Discussing about the relevant topics of the particular subject, students tend to learn about the latest information and new skills. So, it will be necessary for each student to present a seminar on their related topic to the project.

Semester: I

Course Title: POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM

Course Code: MEE1503

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Provide knowledge about the stand alone and grid connected renewable energy systems.
2. Equip with required skills to derive the criteria for the design of power converters forrenewable energy applications.
3. Analyze and comprehend the various operating modes of wind electrical generators and solarenergy systems.
4. Design different power converters namely AC to DC, DC to DC and AC to AC converters forrenewable energy systems.
5. Develop maximum power point tracking algorithms

Course Content

UNIT 1

Introduction **17 Hours**

SOLAR ENERGY CONVERSION: Recent trends in energy consumption World energy scenario Energy sources and their availability Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems - need to develop new energy technologies.

UNIT 2 **13 Hours**

SOLAR ENERGY CONVERSION: Photovoltaic Energy Conversion: Working principle - Energy conversion - Maximum power tracker Photovoltaic system components Factor influencing output System design -Power electronics for photovoltaic power systems - DC Power conditioning converters - AC power conditioners - Line commutated inverters - synchronized operation with grid supply.

UNIT 3 **18 Hours**

WIND ENERGY CONVERSION

Wind Energy Conversion Systems: Basic principle of wind energy conversion nature of wind-Wind survey in India - Power in the wind Components of a wind energy conversion system-Performance of Induction Generators for

WECS-IG-SCIGPMSG-Classification of ale WECS Power electronics converter for variable speed wind turbines-Matrix - Multilevel converters for very high power wind turbines Future trends.

UNIT 4 **12 Hours**

FUEL CELL POWER ELECTRONICS FOR DISTRIBUTED GENERATION (DG): Fuel Cell Working Principle Distributed Generation Fuel cell based energy system for DG-Power electronic topologies for residential stationary fuel cell energy systems -Issues in fuel cell power conditioning system -Energy management system issues –Auxiliary storage.

HYBRID RENEWABLE ENERGY SYSTEMS: Need for Hybrid Systems- Types of Hybrid system-optimization of system components in hybrid power system-Various power quality issues hybrid renewable power system.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electricaal Systems", Oxford University Press, 2009*
- *Rashid M. H. "Power Electronics Hand book", Academic press, 2001.*
- *Rai G.D., "Non Conventional Energy Sources", Khanna publishes, 1993.*
- *Rai. G.D.," Solar Energy Utilization", Khanna publishes, 1993.*
- *Rao. S. & Parulekar, "Energy Technology", Khanna publishers, Fourth edition, 2005.*
- *Pai, B. R. and Ram Prasad, "Power Generation through Renewable Sources of Energy", Tata McGraw Hill, New Delhi, 1991.*

E-Book and Online learning material:

1. https://courses.engr.illinois.edu/ece576/sp2018/Sauer%20and%20Pai%20book%20-%20Jan%202007.pdf
2. https://archive.nptel.ac.in/courses/108/102/108102080/
3. https://archive.nptel.ac.in/courses/108/101/108101004/

Semester: I

Course Title: POWER SYSTEM OPERATIONS AND CONTROL

Course Code: MEE1504

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

To understand real power control and operation.

1. To know the importance of frequency control.
2. To analyze different methods to control reactive power.
3. To understand unit commitment problem and importance of economic load dispatch.
4. To understand real time control of power systems

Course Content

Unit 1 **11 Hours**

LOAD FREQUENCY CONTROL: LOAD FREQUENCY CONTROL: Basics of speed governing mechanism and modeling – speed - load characteristics – load sharing between two synchronous machines in parallel. Control area concept. Load Frequency Control of a single area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC. Two - area system – modeling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system - state variable model.

Unit 2 **19 Hours**

REACTIVE POWER VOLTAGE CONTROL: Basics of reactive power control, Excitation systems – modelling. Static and dynamic analysis: stability compensation generation and absorption of reactive power. Methods of voltage control – tap changing transformer. System level control using generator voltage magnitude setting. Tap setting of OLTC transformer. MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

Unit 3 **18 Hours**

ECONOMIC OPERATION OF POWER SYSTEMS: Statement of economic dispatch problem – cost of generation-Incremental cost curve - co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Economic Aspects of Power Generation: Load curve, load

duration and integrated load duration curves – load demand, diversity, capacity, utilization and plant use factors - NumericalProblems.

Unit 4 **12 Hours**

UNIT COMMITMENT: Statement of Unit Commitment problem – constraints, spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods – Priority list methods - forward dynamic programming approach. Numerical problems on priority-list method using full- load average production cost and Forward DP method.

COMPUTER CONTROL OF POWER SYSTEMS: Need for computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions – SCADA and EMS functions.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Allen J. Wood and Brace F Wollenberg, Power Generation operation and control, John Willey &Sons 2nd edition 1996.*
- *O.I. Elgerd, Electric Energy system Theory : - An Introduction TMH, 2nd Edition.*
- *L.K. Krichmayer, Economic operation of Power Systems, John Willey & Sons, N.Y.*
- *E.L. Grant, Principles of Engineering Economy, Ronald Press, N.Y. 1970.*
- *Related IEEE/IEE publications.*
- *https://archive.nptel.ac.in/courses/108/104/108104052/*

Semester: I

Course Title: BATTERY MANAGEMENT SYSTEMS

Course Code: MEE1505

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Interpret the role of battery management system.
2. Identify the requirements of Battery Management System.
3. Interpret the concept associated with battery charging / discharging process
4. Calculate the various parameters of battery and battery pack
5. Design the model of battery pack

Course Content

UNIT 1 **15 Hours**

Introduction: Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging.

UNIT 2 **15 Hours**

Battery Management System Requirement: Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-ofcharge estimation, Cell total energy and cell total power.

UNIT 3 **15 Hours**

Battery State of Charge and State of Health Estimation, Cell Balancing: Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing.

UNIT 4 **15 Hours**

Modelling and Simulation: Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling

approach, simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs.

Design of battery BMS: Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.*
- *Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.*
- *Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.*
- *Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010.*
- *Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol.9 Springer Science & Business Media, 2008.*

Semester: II

Course Title: DIGITAL PROTECTION OF POWER SYSTEM
Course Code: MEE2550

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Understand the concept and importance of digital Relays
2. Apply mathematical techniques for digital protection
3. Understand the control system techniques for digital protection
4. Understand to develop various protection algorithms

Course Content

UNIT 1 **15 Hours**

Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection, Mathematical background of protection algorithms.

UNIT 2 **15 Hours**

Finite difference techniques, Interpolation formulae, forward, backward and central difference interpolation, Numerical differentiation, Basic elements of digital protection, Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers

UNIT 3 **15 Hours**

Conversion subsystem: the sampling theorem, signal aliasing, Error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, the digital relay as a unit consisting of hardware and Software Sinusoidal wave based algorithms, Sample and first derivative (Mann and Morrisn) algorithm.

UNIT 4 **15 Hours**

Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm, Walsh function based algorithm. Differential equation based algorithms. Travelling Wave based Techniques, Digital Differential Protection of Transformers, Digital Line Differential Protection, and Recent Advances in Digital Protection of Power Systems.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *A.G.PhadkeandJ.S.Thorp,"ComputerRelayingforPowerSystems",Wiley/ResearchstudiesPress,2009*
- *A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEEPress,1999*
- *Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing,2006*
- *S.R. Bhide "Digital Power System Protection" PHI LearningPvt.Ltd.2014*
- *Ravindra P Singh "Digital Power System Protection" PHI learning*

E-Book and Online learning material:

1. https://books.google.co.in/books?id=0reaEkBzX8C&printsec=frontcover&source=gbs_ge_summary_r &cad=0#v=onepage&q&f=false
2. https://epdf.pub › download › computer-relaying-for power-systems-2nd edition/
3. https://nptel.ac.in/courses/108/101/108101039/

Semester: II

Course Title: AC AND DC DRIVES
Course Code: MEE2551

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Basics of Electrical Drives.
2. Develop the closed loop controlled DC drives.
3. The modern trends of DC Dives.
4. The basics methods of speed control of Induction motor.
5. Apply the various speed control methods for controlling the speed of Induction motor.
6. Apply the various speed control methods for controlling the speed of synchronous motor.

Course Content

UNIT 1 **12 Hours**

INTRODUCTION

Electrical Drives, advantages, elements of drive system, drive characteristics, criteria for selection of drive components, dynamics of D.C. motor drives, steady-state stability.

UNIT 2 **18 Hours**

D.C. DRIVES

Introduction, principle of DC motor speed control, phase controlled converters, steady state analysis of three phase converter controlled DC motor Drive, two quadrant three phase controlled DC drive. Introduction, Principle of operation of the chopper, Chopper controlled drives, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit, chopper for inversion, chopper with other power devices, mode of chopper, input to the chopper, steady state analysis of chopper controlled DC Drives, pulsating torques, DC motor Drive with field weakening, four quadrant DC motor drives, converter selection and characteristics

UNIT 3 **10 Hours**

CLOSED-LOOP CONTROL OF DRIVES

Introduction- Basic features of an Electric Drive- Block diagram representation of Drive systems, signal flow graph representation of the

systems, Transfer functions, transient response of closed loop drives systems. Speed control of a separately excited DC drive with inner current loop and outer speed loop

UNIT 4 **20 Hours**

SPEED CONTROL OF INDUCTION MOTOR

Principles of speed control, Various methods of Induction motor drive, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic, Constant Torque and Constant power operation, Implementation of V/f control with slip compensation scheme Speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal.

SPEED CONTROL OF SYNCHRONOUS MOTOR DRIVES

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations.

Types of PM Synchronous motors - Torque developed by PMSM - Model of PMSM - Implementation of vector control for PMSM.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *G.K.Dubey, Power Semi conductor controlled Drives, New Age Int. Pub.*
- *S.B.Dewan, G.R.Slemon & A.Stranghan, Power Semi conductor controlled Drives, Johnwiley Pub.*
- *Shepherd Hullay & Liag, Power Electronics & Motor Control: Cambridge Univ. Press*
- *R.Krishnan, Electric Motor drives – Modelling, Analysis & Control:, PHI India,Ltd.*
- *Vedam Subramanyam, Thyristor Control of Electric Drives.*
- *Vector Control of AC Drives, I. Boldea and S. A. Nasar, CRC Press LLC, 1992.*

Semester: II

Course Title: SMART GRIDS

Course Code: MEE2552

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Appreciate the difference between smart grid and conventional grid
2. Apply smart metering concepts to industrial and commercial installations
3. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
4. Understand integration of renewable energy sources with micro-grid

Course Content

UNIT 1 **18 Hours**

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust and Self-Healing Grid, Present development and International policies in Smart Grid, Introduction to Smart

Meters: Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home and Building Automation, Smart Substations, Substation Automation, Feeder Automation.

UNIT 2 **12 Hours**

Smart Measurement System: Geographic Information System (GIS), Intelligent Electronic Devices (IED) and their application for monitoring and protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU)

UNIT 3 **15 Hours**

Micro-grid and Integration of Renewable Energy sources: Concept of Micro - grid, need and applications of micro-grid, formation of micro-grid, Issues of interconnection, protection and control of micro-grid, Plastic and Organic solar cells, thin film solar cells, Variable speed wind generators, fuel-cells, micro turbines, Captive power plants, Integration of renewable energy sources

UNIT 4 15 Hours

Smart Communication: Advanced Metering Infrastructure (AMI), Home Area

Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Cyber Security for Smart Grid Broadband over Power line (BPL), IP based protocols.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *A. Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE,2011*
- *C.W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009*
- *J. Ekanayake, N. Jenkins, K. Liyanage, "Smart Grid: Technology and Applications", Wiley2012*
- *S.Borlase, "Smart Grid: Infrastructure, Technology and solutions " CRCPress,2012*
- *A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer,2012*

E-Book and Online learning material:

- N.P. Pandey, "Introduction to smart grid", IIT Roorkeehttps://swayam.gov.in/courses/4778-july-2018-introduction-to-smart-grid
- Narayana Prasad Padhy, Premalata Jena, "Introduction to Smart Grid," NPTELhttps://onlinecourses.nptel.ac.in/noc18_ee42/preview
- M. Vadari, M. Balasubramanyan, Distributed Energy – Smart Grid Resources for the Future, IEEE, Coursera.
- Dr. M. Vadari and M. Balasubramanyan, Smart Grids: Electricity for the
- Future, IEEE &EDX
- Laura Ramirez, Pavol Bauer &SeyedmahdiIzadkhast, "Solar Energy: Integration of Photovoltaic Systems in Microgrids", Delf University of Technology,https://www.edx.org/course/solar-energy-integration-photovoltaic-delftx-pv4x-0

Semester: II

Course Title:SCADA SYSTEMS AND APPLICATIONS	**L**	**T**	**P**	**Credits**
Course Code: MEE2553	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes:

Students will be able to:

1. To understand what is meant by SCADA and its functions.
2. To know SCADA communication.
3. To get an insight into its application.

UNIT I **15 Hours**

Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies. Monitoring and supervisory functions, SCADA applications in UtilityAutomation, Industries SCADA.

UNIT II **15 Hours**

Industries SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

UNIT III **15 Hours**

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850. SCADA Communication: various industrial communication technologies-wired and wireless methods and fiber optics. open standardcommunication protocols.

UNIT IV **15 Hours**

SCADA Applications: Utility applications -Transmission and Distribution sector-operations, monitoring, analysis and improvement. Industries - oil, gas. and water. Case studies, Implementation, Simulation Exercises

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested reading

1. *Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society ofAmericaPublications, USA,2004.*
2. *Gordon Clarke, Deon Reynders: "Practical Modern SCADA*

Protocols: DNP3, 60870.5 and RelatedSystems", Newnes Publications, Oxford, UK,2004.

3. *William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006.*
4. *David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003.*
5. *Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electricpower",PennWell 1999.*

Semester: II

Course Title: MATLAB Lab

Course Code: MEE2554

L	T	P	Credits
0	0	4	2

Total Hours: 30

List of experiments:

1. Study of Thyristor controlled D.C Drive.
2. Study of Chopper Fed DC Motor.
3. Study of A.C single phase motor speed control using TRIAC.
4. PWM inverter fed three phase induction motor control using PSPICE/MATLAB/PSIM software.
5. VSI/CSI fed induction motor drive analysis using MATLAB/PSPICE/PSIM software.
6. Study of V/f control operation of three phase induction motor.
7. Study of permanent magnet synchronous motor drive fed by PWM inverter using software.
8. Regenerative/ Dynamic breaking operatation for DC motor study using software.
9. Regenerative/ Dynamic breaking operatation for AC motor study using software.
10. PC/PLC based AC/DC motor control operation.

Semester: II

Course Title: MODERN OPTIMIZATION TECHNIQUES
Course Code: MEE2555

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
2. Understand the relationship between a linear program and its dual, including strong duality and complementary slackness.
3. Perform sensitivity analysis to determine the direction and magnitude of change of a model 's optimal solution as the data change.
4. Solve specialized linear programming problems like the transportation and assignment problems.

Course Content

UNIT 1 **15 Hours**

Introduction

Definition-Classification of optimization problems -Unconstrained and Constrained optimization- Optimality conditions -Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, PSO, Application of fuzzy set theory).

UNIT 2 **15 Hours**

Evolutionary Computation Techniques

Evolution in nature -Fundamentals of Evolutionary algorithms -Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution -Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT 3 **15 Hours**

Particle Swarm Optimization Preparedness: Fundamental principle -Velocity Updating-Advanced operators -Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO- Implementation issues -Convergence issues- PSO based applications to Drive Control

UNIT 4 **15 Hours**

Multi Objective Optimization: Concept of pareto optimality -Conventional approaches for MOOP-Multi objective GA-Fitness assignment -Sharing function- MOGA-Multiobjective PSO and its application in Drive Control.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- D .P .Kothari and J .S .Dhillon,“ Power System Optimization”, 2ndEdition, PHI learning private limited, 2010.
- Kalyanmoy Deb,“ Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.
- Kalyanmoy Deb,“ Optimization for Engineering Design”, Prentice hall of India first edition, 1988.
- Carlos A .Coello Coello, Gary B .Lamont, David A .Van Veldhuizen, “Evolutionary Algorithms for solving Multi Objective Problems”, 2ndEdition, Springer, 2007.

Semester: II

Course Title: RESTRUCTURED POWER SYSTEMS
Course Code: MEE2556

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Identify the need of regulation and deregulation.
2. Understand market architectures in deregulated power system environment.
3. Define and describe the Technical and Non-technical issues in Deregulated Power Industry.
4. Identify and give examples of existing electricity markets.

Course Content

UNIT 1 **15 Hours**

Introduction to restructuring of power industry: Reasons for restructuring of power industry; Understanding the restructuring process, Entities involved, the levels of competition, the market place mechanisms, Sector-wise major changes required; Reasons and objectives of deregulation of various power systems across the world.

Fundamentals of Economics: Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss.

UNIT 2 **15 Hours**

The Philosophy of Market Models: Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design, Cournot, Bertrand and Stackelberg competition model.

Ancillary Service Management: Type and Classification of ancillary services, Sources of reactive power, Black start capability service, Provisions of ancillary services, Markets for ancillary services, Cooptimization of energy and reserve services, Loss of opportunity cost, International practices of ancillary services.

UNIT 3 **15 Hours**

Transmission Congestion Management Transfer capability, Importance of congestion management, Effects of congestion, Classification of congestion management methods, ATC, TTC, TRM, CBM, ATC calculation using DC and AC model, Nodal pricing, Locational Marginal Prices (LMPs), Implications of

nodal pricing, Price area congestion management Capacity alleviation methods, Redispatching, Counter-trade, Curtailment.

UNIT 4 **15 Hours**

Pricing of transmission network usage and loss allocation: Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing paradigm, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and de-merits of different paradigms, Classification of loss allocation methods, Pro-rata methods, Incremental methods, Power flow tracing based allocation.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Lorrin Philipson, H. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub., 1998.*
- *Steven Stoft, "Power system economics: designing markets for electricity", John Wiley and Sons, 2002.*
- *Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub.,2001.*
- *Mohammad Shahidehpour, MuwaffaqAlomoush, "Restructured electricalpower systems: operation, trading and volatility", MarcelDekker.*
- *P. Venkatesh, B.V. Manikandan. S. Charles Raja. A. Srinivasan. Electrical. Power Systems. Analysis, Security and Deregulation, PHI Learning,2012*
- *Loi Lei Lai.Power System Restructuring and Deregulation: Trading, Performance and Information Technology., Wiley,2001*
- *A. R. Abhyankar, S. A. Khaparde, Restructured Power Systems, Narosa,2011*

E-Book and Online learning material:

1. https://nptel.ac.in/courses/108/101/108101005/

Semester: II

Course Title: MODERN CONTROL SYSTEM

Course Code: MEE2559

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Analyze dynamics of a linear system by State Space Representation.
2. Determine the stability of a linear system using pole-placement technique.
3. Formulate and solve deterministic optimal control problems in terms of performance indices.
4. Realize the structure of a discrete time system and model its action mathematically.

Course Content

UNIT 1 **15 Hours**

STATE SPACE ANALYSIS: The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method.

UNIT 2 **15 Hours**

POLE PLACEMENT TECHNIQUES: Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design.

UNIT 3 **15 Hours**

OPTIMAL CONTROL: Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators.

UNIT 4 **15 Hours**

DIGITAL CONTROL SYSTEMS: Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process,

Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi.*
- *I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd.*
- *Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey.*
- *Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley &Sons.*
- *H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.*
- *Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.*
- *Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey.*
- *Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, NewJersey.*
- *Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall.*

E-Book and Online learning material:

1. Energy Management and SCADA, coordinated by IIT Madras, NPTEL,
2. http://www.nptel.ac.in/courses/108106022/8,
3. https://onlinecourses.nptel.ac.in/noc19_ee61/preview

Semester: III

Course Title: RESEARCH METHODOLOGY
Course Code: MEE3600

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

Course Content

Unit 1 **15 Hours**

Research: its concept, nature, scope, need and Objectives of Research, Research types, Research methodology, Research process – Flow chart, description of various steps, Selection of research problem.

Unit 2 **15 Hours**

Research Design: Meaning, Objectives and Strategies of research, different research designs, important experimental designs.

Methods of Data Collection and Presentation: Types of data collection and classification, Observation method, Interview Method, Collection of data through Questionnaires, Schedules, data analysis and interpretation, editing, coding, content analysis and tabulation

Unit 3 **15 Hours**

Sampling Methods: Different methods of Sampling: Probability Sampling methods, Random Sampling, Systematic Sampling, Stratified Sampling, Cluster Sampling and Multistage Sampling. Non probability Sampling methods, Sample size.

Unit 4 **15 Hours**

Report writing and Presentation: Types of reports, Report Format – Cover page, Introductory page, Text, Bibliography, Appendices, Typing instructions, Oral Presentation

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Kothari C.R., "Research Methodology", New Age Publisher*
- *Nargundkar R, Marketing Research, Tata McGraw Hill, New Delhi,2002.*
- *Sekran, Uma, "Business Research Method", Miley Education, Singapore*

Website/Links/Online Portal/ICT

1. https**://**www**.**academia**.**edu**/**
2. https**://**www**.**studeersnel**.**nl
3. https**://**www**.**scribd**.**com

Semester: III

Course Title: Wind and Solar Energy
Course Code: MEE3601

L	T	P	Credits
4	0	0	4

Total hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Understand the basics of wind energy, wind turbines, solar energy and grid integration.
2. Explain and classify wind turbines, instruments for measuring solar radiation, solar collectors, solar cell and solar MPPT techniques
3. Analyze different types of wind generators, solar cell and solar collectors
4. Outline about integration of solar and wind energy systems

Unit 1 **15 Hours**

Wind energy Basics History of wind power, Indian and Global statistics, Characteristics of Wind, principles of wind energy conversion, components of wind energy conversion system, classification of wind turbines- horizontal axis and vertical axis, Betz limit ratio, advantages and disadvantages of wind energy system.

Unit 2 **15 Hours**

Wind turbine technologies Review of modern wind turbine technologies, Fixed and Variable speed wind turbine, Squirrel-cage Induction generator, Wound rotor motor induction generators, Doubly Fed Induction Generator, Synchronous Generators, Permanent Magnet Synchronous Generators and their characteristics.

Unit 3 **15 Hours**

Solar Thermal Physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data. Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

Unit 4 **15 Hours**

Integration of solar and wind Wind power integration into grid-power system stability, economics of grid network, codes and standards for grid integration, grid connected PV systems, control scheme used for single stage grid connected PV system, case study on hybrid system(PV-Wind).

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Studies:

1. *Renewable Energy resources byTiwari and Ghosal, publisher Narosa, 2005.*

2. Solar Photo Voltaics Fundamentals, Technology and application by Chetan Singh Solanki, publisher PHI learning Pvt Ltd, 3rd edition, 2019.

3. Renewable Energy Resources by John Twidell and Tony Weir , publisher Taylor and Francis, 2nd edition 2006.

Semester: III

Course Title: Dissertation-I
Course Code: MEE3602

L	T	P	Credits
0	0	0	0

Course outcomes

1. Identify and define a relevant and significant problem or challenge in the relevant field.
2. Formulate research methodologies for the innovative and creative solutions.
3. Plan and execute tasks utilizing available resources within timelines, following ethical professional and financial norms.
4. Organize and communicate technical and scientific findings effectively in written reports, oral presentation, and visual aid.

Dissertation Phase I can help to identify the problem based on the area of interest through proper literature survey and to foster innovation in design of products, processes or systems based on the identified problem. perform feasibility study by creative thinking and requirement analysis in finding viable solutions to engineering problems. (Dissertation is aimed to bridge the gap between theoretical knowledge and practicalapplication, fostering a well-rounded skill set that prepares students for success in their future engineering careers. Engineering projects often simulate real-world engineering scenarios).

The student is required to submit the synopsis on any topic choosen realted to the electrical engineering.

Semester: III

Course Title: Project
Course Code: MEE3603

L	T	P	Credits
0	0	0	4

Total Hours: 60

Course Learning Outcomes:

The object of Project is to enable the student to take up investigative study in the broad field of Electrical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis under the guidance of a supervisor from the department alone or jointly with a supervisor drawn from R&D laboratory/Industry. This is expected to provide a good initiation for the student in R&D work. The assignment to normally include:

1. Survey and study of published literature on the assigned topic.
2. Define the objective, formulate the problem and prepare an action plan for conducting the investigation.
3. Then perform the required Experiment/Develop a Simulation Model/Solve the Problem/Develop a Design/Explore the feasibility/Conduct a survey etc. depending upon the action plan.
4. Analyse the results and prepare a written report on the study conducted for presentation to the Department.
5. Final seminar, as oral presentation before a departmental committee.

Semester: IV

Course Title: ELECTRIC AND HYBRID VECHILES
Course Code: MEE4650

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to:

1. Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. Understand hybrid drive-train topologies.
3. Attain the knowledge about DC motor drives configuration and control.
4. Understand the selection and sizing of energy storage systems.

Course Content

UNIT 1 **15 Hours**

History of Hybrid and Electric Vehicles: Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics.

UNIT 2 **15 Hours**

Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

UNIT 3 **15 Hours**

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance, Drive system efficiency.

UNIT 4 **15 Hours**

Matching the Electric Machine and Internal Combustion Engine: Sizing the propulsion motor, selecting the energy storage technology, sizing the power electronics devices for energy storage, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *S. Ramirez, R. S. Ortigoza, "Control Design Techniques in Power Electronics Devices",Springer,2011*
- *S.C.Tan,Y.M.LaiandC.K.Tse,"SlidingmodecontrolofswitchingPowerConverters"CRCpress,2012*

E-Book and Online learning material:

1. https://nptel.ac.in/courses/108103009/
2. https://books.google.co.in/books?id=bQFuTCGNYWgC&printsec=frontcover&source=gbs_ge_summary_r &cad=0#v=onepage&q&f=false

Semester: IV

Course Title: DISSERTATION-II
Course Code: MEE4651

L	T	P	Credits
-	-	-	12

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Synthesis of knowledge.
2. To demonstrate the aptitude of applying the own knowledge to solve a specific problem.
3. To mature the knowledge.
4. Able to organize, compile and record all work details in an efficient manner.

Each student will be required to complete a thesis and submit a Dissertation Report on a topic on any of the areas of modern technology related to Electrical Engineering including interdisciplinary fields.

Semester: IV

Course Title: ENTREPRENEURSHIP
Course Code: MEE4652

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Assess the commercial viability of new technologies, business opportunities and existing companies
2. Plan, organize, and execute a project or new venture with the goal of bringing new products and service to the market
3. Carry out scientific research in the field of entrepreneurship
4. Improved your interpersonal and collaborative skills

Course Content

UNIT I **18 Hours**

Introduction to Generic Skills: Importance of Generic Skill Development (GSD), Global and Local Scenario of GSD, Life Long Learning (LLL) and associated importance of GSD.

Managing Self: Knowing Self for Self-Development- Self-concept, personality, traits, multiple intelligence such as language intelligence, numerical intelligence, psychological intelligence etc., Managing Self – Physical- Personal grooming, Health, Hygiene, Time Management, Managing Self – Intellectual development -Information Search: Sources of information, Reading: Purpose of reading, different styles of reading, techniques of systematic reading, Note Taking: Importance of note taking, techniques of note taking, Writing: Writing a rough draft, review and final draft. Managing Self – Psychological, Stress, Emotions, Anxiety-concepts and significance, Techniques to manage the above.

UNIT II **12 Hours**

Managing in Team: Team - definition, hierarchy, team dynamics, Team related skills- sympathy, empathy, co-operation, concern, lead and negotiate, work well with people from culturally diverse background, Communication in group - conversation and listening skills.

UNIT III **10 Hours**

Task Management: Task Initiation, Task Planning, Task execution, Task close out, Exercises/case studies on task planning towards development of skills for task management

Problem Solving: Prerequisites of problem solving- meaningful learning, ability to apply knowledge in problem solving, Different approaches for problem solving. Steps followed in problem solving. Exercises/case studies on problem solving.

UNIT IV **20 Hours**

Entrepreneurship: Introduction, Concept/Meaning and its need, Competencies/qualities of an entrepreneur, Entrepreneurial Support System e.g., District Industry Centres (DICs), Commercial Banks, State Financial Corporations, Small Industries Service Institute (SISIs), Small Industries Development Bank of India (SIDBI), National Bank of Agriculture and Rural Development (NABARD), National Small Industries Corporation (NSIC) and other relevant institutions/organizations at State/National level. Market Survey and Opportunity Identification (Business Planning)- How to start a small-scale industry, Procedures for registration of small-scale industry, List of items reserved for exclusive manufacture in small-scale industry, Assessment of demand and supply in potential areas of growth, understanding business opportunity, Considerations in product selection, Data collection for setting up small ventures.

Project Report Preparation- Preliminary Project Report, Techno-Economic Feasibility Report, Exercises regarding "Project Report Writing" for small projects.

Transaction Modes

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning

Suggested Readings

- *Khanka, S. S. (2006). Entrepreneurial development. S. Chand Publishing.*
- *Desai, V. (2009). Dynamics of entrepreneurial development and management (pp. 119-134). Himalaya Publishing House.*
- *Kennedy, A. (2015). Business development for dummies. John Wiley & Sons*

Semester: IV

Course Title: DISTRIBUTED GENERATION AND MICROGRID	**L**	**T**	**P**	**Credits**
Course Code: MEE4653	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to:

1. Understand the current scenario of Distributed Generation and the need to implement DG Sources.
2. Investigate the different types of interfaces for Grid integration of DGs.
3. Understand the Battery management system and its performance characteristics.
4. Associate different types of micro-grids and interfacing with power electronic units.

UNIT-1 **15 Hours**

INTRODUCTION TO DISTRIBUTED GENERATION Introduction -Distributed Vs Central Station Generation-Traditional Power Systems - T&D system costs-power from Grid as a target for DG- DG planning and comparison: Types of DG Planning Methods- comparison of various types of DG systems.

UNIT-2 **15 Hours**

TYPES OF DG's Renewable resource Distributed Generators-Solar Thermal power Generation-wind powergeneration-Fuel Cell powered DG-Gas Turbine Powered DG-Grid Interconnection optionsTypes of Grid interconnection.

UNIT-3 **15 Hours**

ENERGY STORAGE Introduction-Energy Storage Systems-Battery Storage-Super conducting magnetic Energy Storage (SMES)-Capacitor storage-Mechanical storage-comparison of energy storage technologies

UNIT-4 **15 Hours**

MICRO-GRIDS-I Introduction to micro-grids – Types of micro-grids – Autonomous and non-autonomous grids– Sizing of micro-grids – AC & DC Micro Grids –Comparison- Micro-grids with power electronic interfacing units DG Micro Grid Topologies.

MICRO-GRIDS-II

DC Power source components, application of DC Microgrids - DC Microgr d operations, Some Standards related with DC Power Circuit -Control methods in DC Micro grid -Linear and nonlinear Stability system in DC Micro-grid.

Text Books:

- H. Lee Willis, Walter G. Scott, Distributed Power Generation – Planning andEvaluation, Marcel Decker Press.(unit-1,2,3)
- Robert Lasseter, Paolo Piagi, Micro-grid: A Conceptual Solution, PESC 2004, June 2004.

Suggested Readings

- *F. Katiraei, M.R. Iravani, "Transients of a Micro-Grid System with Multiple Distributed Energy Resources" International Conference on Power Systems Transients (IPST-05) in Montreal, Canada on June 19-23, 2005.*
- *2. Z.Ye R. Walling, N.Miller, P.Du.K.Nelson,"FacilityMicrogrids, General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.*

Semester: IV

Course Title: SMART APPLIANCES AND INTERNET OF THINGS	**L**	**T**	**P**	**Credits**
Course Code: MEE4654	**4**	**0**	**0**	**4**

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to:

- Understand and evaluate the characteristics of smart home appliances.
- Understand the behavior of IoT and its applications.
- Manage smart communication systems with multiple sensors and protocols.
- Design and simulate smart homes and smart cities with IoTs and cloud computing

UNIT-1 **15 Hours**

Modern Domestic Appliances

Solid State Lamps: Introduction - Review of Light sources - white light generation techniques- Characterization of LEDs for illumination application. Power LEDs-High brightness LEDs- Electrical and optical properties. LED driver considerations -Power management topologies - color issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.

UNIT-2 **15 Hours**

IoT Communication Technologies

Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, and Machine-to-Machine Communications. Interoperability in IoT.

UNIT-3 **15 Hours**

IoT Control Technologies and Programming

Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Internet of Things Open-Source Systems Introduction to Python programming, Introduction to Raspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security.

UNIT-4 **15 Hours**

IoT Cloud Computation and Applications

Introduction to SDN. SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud. Fog Computing, Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

Text Books:

- Vinod Kumar Khanna, "Fundamentals of Solid-State Lighting", CRC Press, 1st Edition, 2014.
- Chang-liang Xia, "Permanent Magnet Brushless DC Motor Drives and Controls", John Wiley & Sons Singapore Pte. Ltd, 1st Edition, 2012.
- K. Siozios, D. Anagnostos, D. Soudris, E. Kosmatopoulos, "IoT for Smart Grids Design Challenges and Paradigms", Springer, 1st Edition, 2019.

Suggested Readings

- *Craig Di Louie, "Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications", Fairmont Press, Inc., 1st Edition, 2006.*
- *Robert S Simpson, "Lighting Control: Technology and Applications", Focal Press, 1st Edition,2003.*
- *Arturas Zukauskus, Michael S. Shur & Remis Gaska, "Introduction to solid state lighting", Wiley- Interscience, 1st Edition, 2002.*
- *Mohan, Undeland, and Robbins, "Power Electronics: Converters, Applications, and Design", John Wiley and Sons, 1st Edition, 1989.*
- *www.aboutlightingcontrols.org.*
- https://onlinecourses.swayam2.ac.in/arp19_ap52/preview
- 7. https://onlinecourses.nptel.ac.in/noc19_cs65/preview

Semester: IV

Course Title: ENERGY MANAGEMENT AND AUDITING
Course Code: MEE4655

L	T	P	Credits
4	0	0	4

Total Hours: 60

Course Learning Outcomes:

On successful completion of this course, the students will be able to**:**

1. Identify and describe present state of energy security and its importance.
2. Identify and describe the basic principles and methodologies adopted in energy audit of utility.
3. Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities.
4. Analyze the data collected during performance evaluation and recommend energy saving measures.

Course Content

UNIT 1 **15 Hours**

BASIC PRINCIPLES OF ENERGY AUDIT

Energy audit- definitions, concept, types of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit Need for energy management – energy basics – designing and starting an energy management program – energy audit process. Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting.

UNIT 2 **15 Hours**

ENERGY COST AND LOAD MANAGEMENT

Important concepts in an economic analysis – economic models – time value of money –utility rate structures – cost of electricity – loss evaluation. Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

ENERGY EFFICIENT MOTORS

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance - over motoring - motor

energy audit applications to Systems and equipment such as: electric motors – transformers and reactors – capacitors and synchronous machines.

UNIT 3 **15 Hours**

METERING FOR ENERGY MANAGEMENT Relationships between parameters – Units of measure – typical cost factors – utility meters – timing of meter disc for kilowatt measurement – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid-state meters – metering location vs. requirements – metering techniques and practical examples.

UNIT 4 **15 Hours**

ECONOMIC ASPECTS AND ANALYSIS: Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis- Energy efficient motors-calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Eastop T.D and Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.*
- *Reay D.A., "Industrial Energy Conservation", first edition, Pergamon Press, 1977.*
- *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.*
- *Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.*
- *Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2006.*