BAPATLA ENGINEERING COLLEGE::BAPATLA
(Autonomous)

DEARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Academic RULES & REGULATIONS
(R24 REGULATIONS)
(w.e.f 2024-2025)
Two Years B.Tech. R-24 Schemes and Syllabi-(Draft)

Bapatla Engineering College:: Bapatla

(Autonomous under Acharya Nagarjuna University)
(Sponsored by Bapatla Education Society)
BAPATLA-522102, Guntur District, A.P.
www.becbapatla.ac.in

BAPATLA ENGINEERING COLLEGE::BAPATLA
(Autonomous)

Department
of
Electrical and Electronics Engineering

COURSE STRUCTURE
AND
SYLLABAI FOR TWO YEAR
B.Tech.-(Draft)

HONOR COURSES (16 Credits): Additional courses offered to B.Tech., EEE students to obtain Honors degree in Electrical and Electronics Engineering.

Sl. No	Code	Course Title
1	24EEH4A	Fuel cells and battery management systems.
2	24EEH5B	Machine Learning for Engineering Applications.
3	24EEH6C	Medium Voltage Power Converters.
4	24EEH7D	Evolutionary Algorithms Applications in Power Engineering.
5	24EEH7E	Digital protection of power systems.

MINOR COURSES (16 Credits): Courses offered to non EEE branch B.Tech., students for obtaining Minor degree in Electrical and Electronics Engineering.

Sl.No	Code	Course Title
1	24EEM4A	Elements of Electrical Power Systems.
2	24EEM4B	Principles of Power Electronics & Applications.
3	24EEM5C	Elements of Smart Grid Systems.
4	24EEM6D	Introduction to Hybrid and Electric Vehicles.
5	24EEM7E	Vehicle Communication for Electric Mobility.

OPEN ELECTIVE COURSES:

Sl.No	Code	Course Title
1	24EE704/OA	Non-Conventional Energy Sources.
2	24EE704/OB	Electrical Energy Conservation and Auditing.
3	24EE704/OC	Industrial Electrical Systems.

Bapatla Engineering College:: Bapatla

(Autonomous)

MOOC COURSES:

1. Sensor Technologies: Physics, Fabrication, and Circuits
2. Applied Linear Algebra for Signal Processing, Data Analytics and Machine Learning
3. DC Microgrid and Control System
4. Electronic Modules for Industrial Applications using Op-Amps
5. Introduction to Wireless and Cellular Communications
6. Real-Time Digital Signal Processing
7. Python for Data Science
8. Big Data Computing
9. VLSI Design Flow: RTL to **GDS (**Register-Transfer Level to Graphic Data Stream)
10. Introduction to Industry **4.0** and Industrial Internet of Things.

Honor Course Syllabus

Fuel cells and battery management systems

II B. Tech. – IV Semester (Code: 24EEH4A)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Engineering Chemistry, Basic Electronic Devices.

Course Objectives: To make the students

- **Describe** the fundamental principles, components, electrochemistry, and performance characteristics of fuel
- **Differentiate** and **analyze** various fuel cell types, their operating conditions, system components, and performance limitations.
- **Apply** the concepts of Battery Management Systems to evaluate sensing, communication, protection, and thermal management functionalities.
- **Assess** cell balancing methods, fault detection mechanisms, and safety strategies for reliable battery operation in advanced energy systems.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the fundamental principles, components, electrochemistry, and performance characteristics of fuel cells.
CO2	**Compare** different fuel cell and their operating conditions, system components with performance limitations
CO3	**Apply** the concepts of Battery Management Systems to interpret sensing, communication, protection, and thermal management functions.
CO4	**Evaluate** cell balancing methods, fault detection techniques, and safety strategies in advanced battery systems.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3	2	-	-	2	-	-	-	-	-	-	3	1	1
CO2	3	2	2	2	3	-	-	-	-	-	-	3	2	2
CO3	3	2	2	2	3	-	-	-	2	2	-	2	3	3
CO4	3	3	2	2	3	-	2	-	2	2	1	3	3	3

UNIT-I

Introduction to Fuel Cells: Definition, need, advantages, applications in modern energy systems; Difference between Batteries and Fuel Cells; Historical development of fuel cells.

Fuel Cell Components and Working Principles: Anode, Cathode, Electrolyte, Catalyst, Bipolar plates, Membrane, Fuel cell reactions, thermodynamics; Fuel Cell Electrochemistry: Nernst Equation and reversible potential.
Efficiency of Fuel Cells: voltage efficiency, fuel utilization, Electrochemical kinetics, activation polarization, Butler–Volmer equation and Tafel equation.
Fuel Cell Performance Characteristics: V–I and V–P characteristics, limiting factors.

UNIT-II

Classification of Fuel Cells: By operating temperature and By electrolyte type; Overview & Working of Major Fuel Cell Types: PEMFC, PAFC, MCFC, SOFC, DMFC; **Fuel Cell Losses:** Activation, Ohmic and Concentration over potentials.
Fuel Cell Design & System Components: Single cell design, stack design, fuel processors, humidifiers, compressors, heat exchangers, control units;
Operational Challenges: Fuel crossover, water management, thermal management, durability issues.

UNIT-III

Introduction to Battery Management System (BMS): Role and importance in EVs and energy storage; Functional Blocks of BMS: Voltage, Current, Temperature sensing, High-voltage contactor control, Isolation sensing, Communication Interfaces (CAN, LIN, SPI, I2C); Battery **State Estimations:** State of Charge (SOC) estimation methods (Coulomb counting, OCV, Model-based), State of Health (SOH) estimation techniques, State of Power (SOP);
Cell Balancing & Protection Mechanisms: Over-voltage, under-voltage, over-temperature, over-current protection, Thermal control strategies.
Battery Thermal Management Systems (BTMS): Air cooling, Liquid cooling, PCM-based cooling, Refrigerant-based cooling, Thermal runaway prevention.

UNIT-IV

Cell Balancing Techniques: Passive (Dissipative) balancing, Active balancing: Capacitor-based balancing, Inductive charge transfer, Transformer-based techniques, Flying capacitor balancing, CC/CV Charging Method, Target voltage method; Balancing Optimization and Algorithms;
Battery Fault Detection & Diagnostics: Overcharge, Overvoltage, Over-Temperature, Over-current, Imbalance and Self-Discharge detection, Internal short-circuit detection, Lithium plating detection, Venting and thermal runaway detection, Sudden capacity loss; Fault Reaction Strategies & Safe Operating Requirements for EV Batteries.

List of Experiments:

1. Characterization of a PEM Fuel Cell (V–I and V–P Characteristics)
2. Measurement of Fuel Cell Efficiency
3. Effect of Operating Temperature and Pressure on Fuel Cell Performance
4. Electrochemical Kinetics: Tafel Plot and Exchange Current Determination
5. Water Management and Fuel Crossover Study in Direct Methanol Fuel Cell
6. State of Charge (SOC) Estimation of a Li-ion Battery
7. Cell Balancing Techniques: Passive and Active Methods
8. Battery Thermal Management and Temperature Monitoring
9. Fault Detection and Protection in Battery Systems

Text Books:	1. San Ping Jiang & Qingfeng Li, “Introduction to Fuel Cells: Electrochemistry and Materials” 1st Edition, 2022, Springer. 2. Shichun Yang, Xinhua Liu, Shen Li & Cheng Zhang “Advanced Battery Management System for Electric Vehicles” 1st Edition, 2023, Springer.
References:	1. Yinshi Li “Fuel Cell Fundamentals and Applications” 1st Edition, 2025, Springer. 2. Marc A. Rosen & Aida Farsi “Battery Technology: From Fundamentals to Thermal Behavior and Management” 1st Edition, 2023, Elsevier.
NPTEL Course Links:	1. https://nptel.ac.in/courses/113/105/113105102/ 2. https://nptel.ac.in/courses/112/106/112106318/

Machine Learning for Engineering Applications

III B. Tech. – V Semester (Code: 24EEH5B)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Electronic Devices, – Mathematics (Linear Algebra, Probability & Statistics) – Programming for Problem Solving (preferably Python), Power systems analysis.

Course Objectives: To make the students

- **To introduce** students to the fundamental concepts and terminology of Machine Learning.
- **To enable** students to understand supervised and unsupervised learning methods used in engineering applications.
- **To develop** the ability to apply ML techniques for analyzing electrical system data, including forecasting and fault detection.
- **To provide** knowledge on advanced ML applications related to renewable energy, smart grids, and predictive maintenance.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the basic concepts, workflow, and types of Machine Learning.
CO2	**Apply** supervised and unsupervised learning techniques to solve engineering problems.
CO3	**Evaluate** electrical system data for clustering, anomaly detection, and its performance.
CO4	**Apply** ML concepts to develop solutions for load forecasting, predictive maintenance, and renewable energy prediction.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	2	-	-	-	-	-	-	-	-	3	3	-
CO2	2	3	1	-	-	-	-	-	-	-	-	3	3	-
CO3	3	3	2	-	-	-	-	-	-	-	-	3	3	-
CO4	3	3	2	-	-	-	-	-	-	-	-	3	3	-

UNIT-I

Introduction to Machine Learning: Introduction – Definition and meaning of ML – Basic terms: feature, label, dataset, model, training, testing – Types of ML: supervised learning, unsupervised learning, reinforcement learning – ML workflow from data collection to testing.

UNIT-II

Supervised Learning: Concept of supervised learning – Mapping inputs to outputs – Regression for predicting continuous values – Classification for predicting categories –Steps in training and testing a supervised model – Model evaluation using accuracy, precision, recall, confusion matrix.

UNIT-III

Unsupervised Learning: Meaning of unsupervised learning – Discovering hidden patterns without labels – Clustering for grouping similar electrical data – Principal Component Analysis (PCA) and its use – Anomaly detection in meters and sensors – Identifying abnormal behavior in power systems using unsupervised methods.

UNIT-IV

Advanced ML applications in Electrical Engineering: load forecasting, power demand prediction, energy consumption modelling – Fault detection in power systems – ML for renewable energy prediction – Fault detection in power systems – ML-based transformer fault diagnosis.

Laboratory Experiments using Python:

1. Short-Term Electrical Load Forecasting Using Regression Models.
2. Classification of Electrical Fault Events Using Supervised Learning.
3. Clustering of Electrical Operating Patterns Using Unsupervised Learning.
4. Dimensionality Reduction of Electrical Data Using PCA and Performance Comparison.
5. Anomaly Detection in Smart Meter Readings Using Unsupervised ML Methods
6. Transformer Fault Diagnosis Using Multi-Sensor Machine Learning Models.

Text Books:	1. Dr. K. Venkata Nagendra, "Fundamentals of AI and ML", AkiNik Publications, First Edition, 2021, ISBN: 978-93-91538-84-2. 2. Dr. Saurabh Sureshrao Jadhao, Dr. Ravishankar Shaligram Kankale, Mr. Purushottam Ramesh Bharambe, Mr. Ganesh Narayan Bonde, "AI and Machine Learning in Electrical Systems", VINSA Publishing, First Edition, 2025.
References:	1. Franklin Jino R. E., Thamil Alagan M., Jainulafdeen A., "AI and ML for Electrical and Computer Engineering", Lambert Academic Publishing, First Edition, 2023. 2. Tek Tjing Lie (Ed.), "AI Applications to Power Systems", MDPI Publications, First Edition, 2021.
NPTEL Course Links:	1. https://www.youtube.com/@machinelearning-balaramanr9557

MEDIUM VOLTAGE POWER CONVERTERS

III B. Tech. – VI Semester (Code: 24EEH6C)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Mathematics, Circuit Theory, Introductory Power Electronics.

Course Objectives: To make the students

- To **understand** the principles, operation, and limitations of conventional and multilevel inverters.
- To **apply** various PWM and modulation techniques in the analysis of multilevel and current source inverters.
- To **analyze** different multilevel inverter topologies, their performance, and control strategies.
- To **evaluate** modern power converter technologies for applications such as grid integration, electric vehicles, and data centers.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the operation and characteristics of different inverter topologies and modulation techniques.
CO2	**Apply** PWM, SVM, and harmonic elimination techniques in inverter design and simulation.
CO3	**Analyze** performance parameters such as voltage balancing, harmonic distortion, and efficiency of power converters.
CO4	**Evaluate** and **select appropriate** power converter topologies for real-world applications like EVs and data centers.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	2	1	1	–	–	–	–	2	–	4	2	3
CO2	3	3	3	2	1	–	–	–	–	2	–	4	3	3
CO3	3	3	3	2	2	–	–	–	–	2	–	4	3	3
CO4	3	3	3	2	3	–	–	–	1	2	–	4	3	3

UNIT-I

Introduction: Review of two-level inverters and their PWM schemes. Limitations of two-level inverters and introduction to multilevel inverters. Convectional multilevel inverter typologies.

UNIT-II

Diode clamped multilevel inverter (DCMLI): Three level and Five level DCMLIs, level-shifted PWM, Neutral point voltage balancing, Space Vector Modulation (SVM) and discontinuous SVM, Elimination of common mode voltage, Active Neutral Point Clamped Inverter (ANPCI)-advantages, disadvantages and its applications.

UNIT-III

Cascade H-bridge (CHB) multilevel inverter (MLI): Symmetrical and asymmetrical topologies, level-shifted PWM, phase-shifted PWM, hybrid PWM and SVM. Concept of coupling transformer-less grid connected applications, Topologies of modular multilevel inverters (MMI). **Reduced switch count MLIs**: Introduction, classification, operation of T-type, multilevel dc link, switched series parallel source and other topologies.

UNIT-IV

PWM current source inverters: Trapezoidal modulation, selective harmonic elimination and SVM, Load-commutated inverters (LCI).

Low Voltage High Current Power Supplies: Architecture of Data centers, Power converters for modern microprocessor and computer loads-Switched Capacitor topology, LLC Resonant converter.

Laboratory Experiments:

1. Performance measurement and analysis of isolated DC-DC flyback converter.
2. Simulation of Fixed PWM, Sinusoidal PWM For an Inverter.
3. Simulation of H Bridge Inverter With R-Load.
4. Simulation of Three Level Diode Clamped MLI With R Load.
5. Simulation of Three Level Capacitor Clamped MLI With R Load.
6. Simulation of MLI With Reduced Switch Configuration.
7. Design and Development of Bidirectional Converter Based on V2G And G2V Operation.
8. Performance Evaluation of a Multifunctional Integrated DC–DC Converter for Electric Vehicles Using MATLAB/Simulink.

Text Books:	1. M. H. Rashid, Power Electronics Handbook, Butterworth-Heinemann Inc, 2024, 5th Edition. 2. Abraham I. Pressman, Keith Billings &Taylor Morey, Switching Power Supply Design, McGraw Hill International, 2009, 3rd Edition.
References:	1. High Power Converters and AC Drives, Bin Wu, Wiley-Inter science, 2017, 2nd Edition. 2. Pulse Width Modulation for Power Converters: Principles and Practice, D. Grahame Holmes and Thomas A. Lipo, IEEE Press, 2003. 3. https://ieeexplore.ieee.org/document/10428839/authors#authors
NPTEL Course Links:	1. https://onlinecourses.nptel.ac.in/noc23_ee20/preview 2. https://www.youtube.com/watch?v=NdGtyOZ6Vv8 3. NPTEL :: Electrical Engineering - Pulse Width Modulation for Power ElectronicConverters https://onlinecourses.nptel.ac.in/noc21_ee01/preview 4. http://digimat.in/nptel/courses/video/117107485/L26.html

	5. https://www.scribd.com/document/839041693/EE3011-MULTILEVEL-POWER-CONVERTERS-LABORATORY

Evolutionary Algorithms Applications in Power Engineering

IV B. Tech. – VII Semester (Code: 24EEH7D)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Power Systems Analysis.

Course Objectives: To make the students

- **Introduce** students to the fundamental concepts and classifications of optimization and evolutionary algorithms.
- **Teach** the mathematical foundations and operational mechanisms of simulated annealing, tabu search, genetic algorithms, and particle swarm optimization (PSO).
- **Enable** students to design and implement genetic algorithm and PSO-based solutions for Economic Dispatch problems, simulated annealing and tabu search algorithms for Unit Commitment problems.
- **Guide** students to formulate Single and Multi Objective Optimal Power Flow problems and solve them using PSO and other optimization techniques.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Describe** the fundamental concepts, types, and classifications of optimization and evolutionary algorithms used in power system problems.
CO2	**Appraise** and explain the mathematical principles and functioning of simulated annealing, tabu search, genetic algorithms, and particle swarm optimization (PSO).
CO3	**Develop** and implement genetic algorithm and PSO-based solutions for Economic Dispatch problems, and simulated annealing and Tabu search algorithms for Unit Commitment problems.
CO4	**Formulate** single and multi-objective Optimal Power Flow problems and apply PSO and other relevant optimization techniques to solve them effectively.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2	2	1	1	3	3	-	3	2	-	2	3	3	-
CO2	3	3	3	3	3	2	-	3	2	-	2	3	3	-
CO3	3	3	3	3	3	2	-	3	2	-	2	3	3	-
CO4	3	3	3	3	3	2	-	3	2	-	2	3	3	-

UNIT-I

Optimization and Evolutionary Techniques: Introduction**,** problem formulation, Conventional Techniques (Classic Methods), Evolutionary Techniques Concepts - Evolutionary Techniques, Evolutionary Computation, Genetic Algorithm, Evolution Strategies and Evolutionary Programming, Differential Evolutions, Particle Swarm, Tabu Search, Simulated Annealing, Stochastic Approximation, Fuzzy.

UNIT-II
Mathematical Optimization Techniques: Some Static Optimization Techniques-Unconstrained Optimization, Constrained Optimization, Simulated Annealing Algorithm (SAA)- Physical Concepts, A General Simulated Annealing Algorithm, Cooling Schedules, Tabu Search Algorithm-Tabu List Restrictions, Aspiration Criteria, Stopping Criteria, General Tabu Search Algorithm, The Genetic Algorithm (GA)- Solution Coding, Fitness Function, Genetic Algorithms Operators, Constraint Handling (Repair Mechanism), A General Genetic Algorithm, Particle Swarm Optimization (PSO) Algorithm-Basic Fundamentals of PSO Algorithm-General PSO Algorithm
UNIT-III
Economic Dispatch (ED) : The Objective Function-The Production Cost, The Start-Up Cost, The Constraints, Algorithm for the Economic Dispatch Problem, Genetic Algorithms for Economic dispatch, PSO Algorithm for Economic dispatch **Unit Commitment Problems (UCP):** The Simulated Annealing Algorithm (SAA) for Solving UCP formulation, General Tabu Search Algorithm- Tabu Search Algorithm for Unit Commitment, Advanced Tabu Search (ATS) Techniques-Flow chart of the proposed ATSA for UCP, Genetic Algorithms for Unit Commitment, Implementation of a Genetic Algorithm to the UCP
UNIT-IV
Optimal Power Flow: General OPF Problem Formulations-The Objective Functions, The Constraints, Optimization Algorithms for OPF, Particle Swarm Optimization (PSO) Algorithm for the OPF Problem, Minimization of Generation Fuel Cost, Multi objective OPF Algorithm, Multi-objective OPF Formulation, General Steps for Solving Multi-Objective OPF Problem, Weighting method, Hierarchical Cluster Technique. **List of Experiments:** 1. Solve Economic Dispatch problems using GA and compare the results with classical methods under different cost function models. 2. Apply PSO for solving the Economic Dispatch problem and analyze its performance for multi-unit power systems. 3. Design Differential Evolution algorithm for solving the Economic Dispatch problem and analyze its performance for multi-unit power systems. 4. Develop Simulated Annealing for Unit Commitment considering start-up costs, minimum up/down constraints, and ramp rate limitations. 5. Develop and apply a Genetic Algorithm to solve the Unit Commitment problem and compare feasibility and cost performance. 6. Apply PSO to minimize the total generation fuel cost in Optimal Power Flow considering system constraints. 7. Design Tabu Search for solving the Unit Commitment problem and evaluate scheduling quality using tabu list and aspiration rules.

Text Books:	1. S.A. Soliman and A.H. Mantawy, Modern Optimization Techniques with Applications in Electric Power Systems, Energy Systems, Springer Science, 2012. DOI: 10.1007/978-1-4614-1752-1_1
References:	1. D.P. Kothari and J.S. Dhillon, Power System Optimization, Tata McGraw-Hill Education, 2025.

	2. J. Zhu, Optimization of Power System Operation (2nd Edition), Wiley-IEEE Press, 2015.
NPTEL Course Links:	1. Economic Operations and Control of Power Systems Link: https://onlinecourses.nptel.ac.in/noc25_ee115/preview 2. Evolutionary Computation for Single and Multi Objective Optimization Link: https://nptel.ac.in/courses/112103301 3. Economic Operation and Control of Power System Link: https://nptel.ac.in/courses/108104191

Digital protection of power systems

IV B. Tech. – VII Semester (Code: 24EEH7E)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Power system protection, Digital Signal processing.

Course Objectives: To make the students

- **To explain** the structure and functional components of digital relays including their role in system protection.
- **To gain** knowledge on different algorithms of Signal processing techniques for the power system.
- **To understand** the principles and design of digital protection schemes for major power system components.
- **To introduce** the new developments in protective relaying and applications.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the functional components of digital relays, including signal conditioning and analog-to-digital conversion.
CO2	**Apply** the suitable signal processing technique algorithms for protection.
CO3	**Implementing** the digital relay–based protection schemes used for major power system components.
CO4	**Identify** the new developments in protective relaying and applications.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	2	-	1	1	-	-	-	-	-	-	1	2	3
CO2	3	2	2	3	3	-	-	-	-	-	-	3	3	3
CO3	3	2	2	2	2	-	-	-	-	-	-	3	3	3
CO4	3	2	2	2	2	-	-	-	-	-	-	3	3	3

UNIT-I

Introduction to Digital Relays: Need for digital protection, Introduction to Digital Sub-stations, the functional block diagram and Basic elements of a digital relay and their functions, signal conditioning subsystem, conversion subsystem, digital relay subsystem including the analog-to-digital conversion process, quantization errors, and different ADC types.

UNIT-II

Signal processing techniques: Sinusoidal based algorithms, Fourier analysis-based algorithms, Least squares based algorithm, Discrete Fourier Transforms, Wavelet Transforms, Kalman Filtering.

UNIT-III	
Protection Schemes: Protection schemes for various power system components like generators, transformers, Transmission lines and bus bars using digital relays.	
UNIT-IV	
Applications of Fuzzy Logic and ANN for power system component protection, Fault location algorithm, Wide Area Monitoring and Protection. **Laboratory Experiments**: 1. Numerical over current relay 2. Numerical earth fault relay 3. Testing of numerical differential relay using universal relay test system. 4. Testing of numerical distance relay using universal relay test system. 4. Protection of Induction motor using wavelets in MATLAB/PYTHON 5. Protection of transmission line using wavelets in MATLAB/PYTHON 6. Protection of Transformer using wavelets in MATLAB/PYTHON. 7. Simulate symmetrical and unsymmetrical faults (single line-to-ground, line-to-line, etc.) on a test system using MATLAB/PYTHON. 8. Transient signal analysis by using Wavelets in MATLAB.	
Text Books:	**TEXT BOOKS:** 1. A.G. Phadke, James S.Thorp, Computer Relaying for Power Systems, John-Wiley and sons, 2009, 2nd Edition. 2. Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, Digital Signal Processing in Power System Protection and Control, Springer Publication, 2015, 1st Edition. 3. S.R.Bhide "Digital Power System Protection", PHI Learning Pvt. Ltd, New Delhi, 2014.
References:	**REFERENCE BOOKS:** 1. Singh, Digital Power System Protection, Prentice-Hall of India Pvt. Limited, 2014, 2nd Edition. 2. Orhan Gazi, Understanding Digital Signal Processing, Springer, 2017, 2nd Edition. 3. Johns, Digital Protection for Power Systems, IET Power Series, 2023. 4. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 4th edition,2011.
NPTEL Course Links:	1. https://nptel.ac.in/courses/108/101/108101039 2. https://onlinecourses.nptel.ac.in/noc22_ee46/preview 3. https://nptel.ac.in/content/storage2/courses/108101039/download/Lecture-1.pdf

Minor Course Syllabus

Elements of Electrical Power Systems

II B. Tech. – IV Semester (Code: 24EEM4A)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: None.

Course Objectives: To make the students

- **Provide** knowledge of conventional and renewable methods of electric power generation.
- **Introduce** the economics of power generation,
- **To provide** fundamental knowledge of AC distribution systems, overhead line insulators, and insulated Cables.
- **Build** awareness on sustainability, reliability, and emerging technologies in modern power systems.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Annotating** the operation of conventional generating stations and renewable sources of electrical power
CO2	**Compare and analyze** the power economics and power tariff methods
CO3	**Appraising** the operation of AC distribution systems, overhead insulators and insulated cables.
CO4	**Evaluate** power system sustainability and reliability.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	2	1	-	-	1	1	-	-	2	-	3	1	1
CO2	3	2	1	-	1	-	2	-	-	1	-	3	2	1
CO3	3	2	2	-	1	-	-	-	1	2	3	3	2	2
CO4	3	2	1	-	2	2	3	1	-	1	-	2	3	2

UNIT-I

Introduction: Typical Layout of an Electrical Power System Present Power Scenario in India.
Generation of Electric Power Conventional Sources: Hydro station, Steam Power Plant, Nuclear Power Plant and Gas Turbine Plant**.**
Renewable energy Sources: Wind Energy, Fuel Cells, and Solar Energy, Tidal

UNIT-II

Economics of Generation: Introduction, definitions of connected load, maximum demand, demand factor, load factor, diversity factor, Load duration curve, number and size of generator

units. Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff on charge to customer.	
UNIT-III	
AC Distribution: Introduction, single line diagram of a typical power system, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, Selection of site and layout of substation. **Overhead Line Insulators:** Introduction, types of insulators, Potential distribution over a string of suspension insulators, Methods of equalizing the potential, testing of insulators. **Insulated Cables:** Introduction, insulation, insulating materials, Extra high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables.	
UNIT-IV	
Sustainability of Power System: Environmental sustainability, economic sustainability, social sustainability, concept of power system reliability. **Technology Drivers (Qualitative):** Technologies associated with Distributed energy Resources (e.g. Fuel cells, Micro turbines, Solar PV) **List of Experiments/Case studies:** 1. Power versus wind-speed and Cp (power coefficient) curves of a Wind Turbine. 2. Solar PV Panel I–V & P–V Characteristics under Variable Irradiance. 3. Measure capacitance per km and insulation resistance of single core/three-core cable sample. 4. Y-bus & Z-bus formation and short-circuit study for a given network (MATLAB). 5. Calculation of open circuit and short circuit parameters of overhead transmission line. 6. Comparative Study — Overhead Line vs Underground Cable (Loss & Cost Estimation) 7. Electricity Tariff Calculation — Compute electricity bills under different tariffs (flat, Time of day tariff, demand charge) and show impact on consumers/utility revenue. 8. Case study-Determine number and sizes of units to meet load economically.	
Text Books:	1. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New-Age International, 2009, 2nd Edition. 2. C.L. Wadhwa, Electrical Power Systems, New-Age International, 2009, 5th Edition. 3. W.D. Stevenson, Elements of Power System Analysis, McGraw Hill, 1984, 4th Edition.
References:	1. Nava Raj Karki, Rajesh Karki, Ajit Kumar Verma, Jaeseok Choi, Sustainable Power Systems, Springer Singapore, 2017. 2. Lingfeng Wang, Modeling and Control of Sustainable Power Systems, Springer-Verlag Berlin Heidelberg, 2012. 3. M.V. Deshpande, Elements of Electrical Power Station Design, Wheeler Pub.1998, 3rd Edition.
NPTEL Course Links:	1. https://www.coursera.org/learn/electric-power-systems 2. https://onlinecourses.nptel.ac.in/noc19_ee62/preview

Principles of Power Electronics

II B. Tech. – IV Semester (Code: 24EEM4B)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basics of Mathematics, Basic Electrical and Electronics Engineering.

Course Objectives: To make the students

- **To Understand** the Power Electronics devices its protection.
- **To Analyze** AC to DC Conversion circuits.
- **To Analyze** the operation of inverters PWM techniques.
- **To Analyze** the operation of DC-DC choppers and AC Voltage controllers.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the operation, characteristics, and protection of power semiconductor devices.
CO2	**Analyze** the performance of single-phase and three-phase AC–DC converters under various load conditions and power quality factors.
CO3	**Apply** inverter and DC-DC converter topologies with suitable PWM techniques for effective power conversion.
CO4	**Evaluate** AC-AC converters and electric drive systems to select appropriate drives for different applications.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	**POs**											**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	2	-	3	-	-	-	-	-	2	-	-	-	-	-
CO2	3	-	-	-	3	-	-	-	-	-	-	-	2	-
CO3	-	-	3	-	-	2	-	-	-	-	-	-	-	3
CO4	3	-	3	-	-	2	-	-	-	-	-	-	-	-

UNIT-I

Introduction to Power Electronics devices protection and Power Transistors:

Thyristor family devices, principle of operation, selection and protection, Firing circuits, Commutation,ratings.

UNIT-II

AC to DC Converters:

Uncontrolled, semi-controlled, fully controlled and dual converters in single-phase and three phase configurations operation with R, R-L load, Issues of Power factor.

UNIT-III
DC to AC Converters: Basics of dc to ac conversion, inverter circuit configurations and principle of operation for single and three-phase configurations, Single, Multiple, Square wave and sinusoidal PWM control methods and harmonic control.
UNIT-IV
DC-DC Converters and AC-AC Converters: Introduction to dc-dc conversion, buck, boost converters. Introduction to ac to ac conversion, single-phase ac voltage controller circuit configuration with R load Analysis. Cyclo-converters: single-phase step up and step down circuit configuration. **List of Experiments:** 1. Study of Static Characteristics of SCR, MOSFET & IGBT. 2. Study of single-phase half-controlled, Fully-Controlled bridge converter with R, RL and RLE load. 3. Study of three-phase half-controlled and Fully- Controlled bridge converter with R, RL and RLE load. 4. Study of single-phase dual converter with *RL* loads. 5. Study of Parallel inverter with R & *RL* loads. 6. Analysis of steady-state characteristics of DC-DC Buck-Boost converter with Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM). 7. Analysis of frequency spectrum for 3-Phase Pulse width modulation (PWM) & non-Pulse width modulation (PWM) inverter using MATLAB Simulink. 8. Closed loop speed control scheme (slip speed compensation) of induction motor by constant *V/f* using MATLAB Simulink.

Text Books:	1. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 3rd Edition, 2014. 2. Power Electronics by M.D.Singh and Khanchandani TMH, 2nd Edition, 2017. 3. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design",John Wiley & Sons, 3rd Edition 2007.
References:	1. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 3rd Edition 2020. 2. L.Umanand,"Power Electronics:Essentials and Applications", Wiley India, 1st Edition 2009. 3. Power Electronics by P.S. Bhimbra, Khanna publications, 6rd Edition 2019.
NPTEL Course Links:	1. NPTEL ::Electrical Engineering- FPE: Fundamental of Power Electronics 2. https://onlinecourses.nptel.ac.in/noc21_ee01/preview

Elements of Smart Grid Systems

III B. Tech. – VI Semester (Code: 24EEM5C)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Electrical and Electronics Engineering, Engineering Chemistry.

Course Objectives: To make the students

- **To provide** fundamental knowledge of Smart Grids, their need, domains, priority areas, regulations, and the role of non-conventional energy.
- **To introduce** smart grid architecture, standards, technologies, and key components such as SCADA and AMI.
- **To familiarize** students with energy storage technologies, Battery Management Systems, and communication systems including WAMS and IoT.
- **To develop** the ability to apply optimization, artificial intelligence, and evolutionary algorithms in power system and smart city applications.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Understand** the concepts, structure, and regulatory aspects of Smart Grids and their integration with renewable energy sources.
CO2	**Appraising** smart grid architecture, standards, technologies, and components for efficient system operation.
CO3	**Demonstrate** knowledge of energy storage systems, BMS, and communication technologies like WAMS and IoT in Smart Grids.
CO4	**Apply** computational techniques, AI, and evolutionary algorithms to solve practical power system and smart city problems.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO2	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO3	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO4	3	3	3	3	2	3	-	-	-	-	-	3	3	3

UNIT-I

Introduction: Introduction to Smart Grid, need for smart grid, smart grid domain, smart grid priority areas, regulatory challenges, Role of non-conventional Energy sources in smart grid, smart-grid activities in India.

UNIT-II

Smart Grid Architecture and elements: Smart grid architecture, Standards for Smart Grid system, elements and Technologies of Smart Grid System, supervisory control and data acquisition system (SCADA), advanced metering infrastructure (AMI).

UNIT-III

Introduction to energy storage devices: Different types of energy storage technologies, Battery management system (BMS).

Smart Grid Communication: Introduction to Communication Technology, Wide area Monitoring Systems (WAMS)- Introduction to Internet of things (IoT)- Applications of IoT in Smart Grid

UNIT-IV

Smart cities: Smart city pilot projects, essential elements of smart cities, active distribution networks.

Computational Tools for Smart Grid: Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch –Artificial Intelligence techniques and applications in power system. Evolutionary Algorithms in power system such as Particle Swarm Optimization (PSO), Genetic Algorithm (GA).

List of Experiments:

1. Simulation of conventional vs. smart grid operation under load variation.
2. Modeling and analysis of integration of renewable energy sources (solar/wind) into a grid.
3. IoT-based real-time monitoring of load and generation.
4. Simulation of SCADA-based monitoring of a distribution network.
5. Simulation of different types of energy storage systems: Battery Energy Storage System (BESS)
6. Data acquisition and control using MATLAB/Simulink for distributed energy resources.
7. Economic Load Dispatch (ELD) using classical optimization techniques in MATLAB.
8. Optimal Power Flow (OPF) Analysis Using Genetic Algorithm (GA) in MATLAB/Simulink.

Text Books:

1. KrishanArora,SLataTripathi,SPadmanaban,SmartElectricGridsystems:DesignPrinciple, Modernization and Techniques, CRC Press, New York, 2-23.
2. K S Manoj, Smart Grid: Concepts to Design, Kindle edition, 2-19.

References:

1. Janaka Ekanayake, Liyanage, Wu, Akihiko Yokoyama, Jenkins, Smart Grid: Technology and Applications, Wiley Publications, 1^{st} Edition, 2-15.
2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, , Wiley, IEEE Press., 1^{st} Edition, 2-16.
3. A.G. Phadke andJ.S. Thorp, Synchronized Phasor Measurements and their Applications, Springer, 2-17, 2^{nd}Edition.
4. T. Ackermann, Hoboken, Wind Power in Power Systems, N J, USA, John Wiley, 2-12, 2^{nd}Edition.

NPTEL Course Links:

1. https://onlinecourses.nptel.ac.in/noc23_ee6-/preview
2. https://onlinecourses.nptel.ac.in/noc21_ee68/preview
3. https://www.coursera.org/lecture/electric-power-systems/smart-grid-utilities-consumers-TSfB

Introduction to Hybrid and Electric Vehicles

IV B. Tech. – VII Semester (Code: 24EEM6D)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Electrical and Electronics Engineering, Principles of Power Electronics & Applications.

Course Objectives: To make the students

- **Understand** the basic principles of hybrid and electric vehicles (EVs and HEVs), their evolution, and the role they play in sustainable transportation.
- **Explore** the working concepts of electric and hybrid drivetrains, including the structure, operation, and energy flow of these systems.
- **Familiarize** students with the key components used in hybrid and electric vehicles, including motors, batteries, and energy management systems.
- **Introduce** students to the current policies and trends in the EV sector, as well as future developments in vehicle technologies, energy storage, and grid integration.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Explain** the fundamental concepts of hybrid and electric vehicles, their advantages, and their contribution to sustainable transportation.
CO2	**Describe** the operation of electric and hybrid drivetrains, including powertrain layouts, energy flow, and regenerative braking systems.
CO3	**Identify** and explain the key components of hybrid and electric vehicles, such as electric motors, batteries, and energy management systems.
CO4	**Appraising** the current trends, policies, and challenges surrounding the adoption of electric and hybrid vehicles, including future technologies and grid interaction concepts.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	2	2	2	-	-	-	-	2	2	-	3	2	2
CO2	3	2	3	3	-	-	-	-	2	2	-	3	2	2
CO3	3	2	3	2	-	-	-	-	2	2	-	3	2	2
CO4	3	2	3	2	-	-	-	-	2	2	-	3	2	2

UNIT-I

Introduction to Electric and Hybrid Vehicles: Basics of hybrid and electric vehicles, starting with their evolution, benefits, and role in sustainable transportation. It will discuss the environmental and economic factors influencing the rise of EVs and HEVs. The unit introduces the basic vehicle dynamics, performance parameters, and energy requirements, along with an

overview of government policies, standards, and incentives that are promoting the adoption of EVs in India, such as NEMMP and FAME schemes.
UNIT-II
Electric and Hybrid Drivetrain Systems: Basic concepts of electric and hybrid drivetrains, including simple powertrain layouts for both types of vehicles. The working principles of series, parallel, and series-parallel hybrid systems will be presented. The concept of regenerative braking will also be covered, as well as the benefits of energy recovery in electric vehicles. Basic drivetrain control strategies and their impact on vehicle performance will also be discussed.
UNIT-III
Key Components of Electric and Hybrid Vehicles: Fundamental components used in EVs and HEVs, including electric motors, batteries, and controllers. The focus will be on understanding the role of different types of motors (DC, induction, and permanent magnet motors) and their basic working principles. It will also cover battery types (Li-ion, lead-acid), their role in energy storage, and an introduction to energy management strategies used in these vehicles.
UNIT-IV
EV Policies, Trends, and Future Directions: Current EV and hybrid vehicle policies and trends in the automotive industry. Topics will include an overview of global and Indian EV policies, charging infrastructure, and sustainability challenges. The future of electric and hybrid vehicles will be discussed, with a focus on upcoming technologies, energy storage systems, and the potential for grid integration and vehicle-to-grid (V2G) systems. **List of Experiments:** 1. Simulation of Basic Electric Vehicle Dynamics. 2. Analysis of Hybrid Powertrain Layouts. 3. Regenerative Braking Simulation. 4. DC Motor Control for EV Propulsion. 5. Induction Motor and BLDC Motor Operation. 6. Battery Characteristics and State-of-Charge Estimation. 7. Energy Management Strategy Simulation. 8. Vehicle-to-Grid (V2G) and Charging Simulation.

Text Books:	1. I. Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. 2. M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design , 2nd ed., CRC Press, 2005. 3. J. Larminie and J. Lowry, Electric Vehicle Technology Explained, 2nd ed., Wiley, 2003.
References:	1. C. Mi, M. A. Masrur, and D. W. Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2011. 2. A. Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.

NPTEL Course Links:	1. **https://www.youtube.com/watch?v=W_Fp7nGgz9k** 2. **https://www.youtube.com/watch?v=_xM7X8k9g0s**

Communication Networks for Electric Vehicles

IV B. Tech. – VII Semester (Code: 24EEM7E)

Lectures	3	Tutorial	0	Practical	2	Credits	4
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Digital Electronics, Fundamentals of Computing.

Course Objectives: To make the students

- **Understand** critical automotive technologies including Electronic Control Units (ECUs) in-vehicle networking, and unified diagnostics services .
- **To develop** capability in using automotive software tools such as TSMaster, PCAN tools, CANdb++,DMS Module.
- **To gain** practical skills in CAN communication, diagnostic protocols, and test automation.
- **To prepare** students for project-based learning addressing real-world automotive software and system development challenge.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Interpret** and simulate CAN communication and diagnostics for automotive ECUs.
CO2	**Utilize** automotive software tools for protocol testing, diagnostics, and network simulation.
CO3	**Execute** real-life automotive projects like Remote Keyless Entry (RKE), Instrument Cluster simulation, and Seat Belt Reminder Warning systems.
CO4	**Evaluating** the automotive software development lifecycle including Agile SCRUM and V-Model verification and validation processes.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	2	3	3	3	3	3	3	-	-	-	-	3	3
CO2	3	3	3	3	3	3	3	3	-	-	-	-	3	3
CO3	3	3	3	3	3	3	3	3	-	-	-	-	3	3
CO4	3	3	3	1	2	3	3	3	-	-	-	-	3	3

UNIT-I

Introduction to Auto Electronics: Overview of Auto Electronics & EV, Automotive Technologies: ECUs, in-vehicle networking, UDS (Unified Diagnostic Services), CAN protocol.

Automotive Software Tools: TS-Master, PCAN-View, PCAN Explorer, CANdb++, Arduino Software capabilities and usage scenario.

UNIT-II
CAN Communication and Network Simulation: CAN APIs and Communication protocol, CAN Matrix and Database implementations Testing with PCAN-USB, PCAN-View hardware Rest Bus Simulation (RBS) using TS-Master Test automation technique, Practical exercises with PCAN-USB and hardware testing.
UNIT-III
Diagnostic Protocols and Automation: Unified Diagnostic Services (UDS) session control and security access, Diagnostic request simulation and response handling, Automation scripts using CAPL and Python for CAN/UDS testing.
UNIT-IV
Advanced Automotive system: Autonomous vehicle basics and sensor fusion, vehicle-to-Everything(V2X) Communication concepts, Electrical Vehicle battery management systems (BMS) overview. **Advanced Driver Monitoring Systems (DMS):** Overview and importance of DMS in automotive Safety, AI techniques used- computer vision, Machine learning, sensor and hardware integration, real time monitor and alert mechanisms. **Practical Exercises** 1.CAN Communication Initialization and Message Transmission using MCP2515 CAN Controller 2.Development of CAN Database and Signal Handling with CANdb++ Editor 3.Simulation of ECU Communication on Prototype Platforms using PCAN-View and PCAN Explorer 4. Rest Bus Simulation (RBS) Setup and Execution using TS-Master 5.RImplementation of Diagnostic Protocols: UDS Session Control and Security Access on CAN Network 6.TAutomation of Diagnostic Communication Tests using CAPL Scripting 7. Remote Keyless Entry (RKE) System - Software in the Loop (SIL) Development and Testing 8. Instrument Cluster Simulation and Test Automation including CAN Message Integration 9. Fault Injection and Diagnostic Trouble Code (DTC) Generation with Real-time Monitoring and Analysis 10. AI-based Driver Monitoring System (DMS) Experiment. i. Setup and integration of camera-based monitoring hardware. ii. Implementation of AI algorithms for driver alertness detection. iii. Real-time data capture and alert mechanism simulation.

Text Books:	1. Automotive Embedded Systems Handbook," Nicolas Navet and Francoise Simonot-Lion, Wiley-IEEE Press, 1st Edition, 2007. 2. "Controller Area Network Protocols and Automotive Applications," Konrad Etschberger, SAE International, 1st Edition, 2001. 3. “"Understanding Automotive Electronics," William B. Ribbens, 6th Edition, 2017 4. "Python Programming for Embedded Systems," Timothy Oliphant, Packt Publishing, 1st Edition, 2017.

	5. "Automotive Diagnostic Systems: Understanding OBD-I & OBD-II," Mandy Concepcion, Pearson, 1st Edition, 2005
References:	1. "Automotive Electronics: Automotive CAN and LIN Communications," Jiming Song, Wiley-IEEE Press, 1st Edition, 2012 2. "The Art of Electronics," Paul Horowitz and Winfield Hill, 3rd Edition, 2012 3. "Vehicle Network Security: Automotive CAN and Ethernet Security," Yavuz Parlar, Wiley, 1st Edition, 2020 4. "Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market," Gianfranco Pistoia, Elsevier, 2nd Edition, 2013. 5. "Artificial Intelligence in Automotive Engineering," Markus Maurer et al. (Editors), Springer, 1st Edition, 2016.
NPTEL Course Links:	1. https://onlinecourses.nptel.ac.in/noc21_me51/preview 2. https://onlinecourses.nptel.ac.in/noc21_me51/preview

Non-Conventional Energy Sources

IV B. Tech. – VII Semester (Code: 24EE704/OA)

Lectures	3	Tutorial	0	Practical	0	Credits	3
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Electrical and Electronics Engineering.

Course Objectives: To make the students

- **Acquire** knowledge about alternate energy sources.
- **Discuss** the concepts of different solar generation techniques.
- **Gain** knowledge about wind energy conversion.
- **Describe** generation of energy from Ocean and Geothermal connectivity

Course Outcomes: After completion of this course, Students will be able to

CO1	**Describe** the Importance of Non- conventional Energy sources.
CO2	**Construct** different types of solar power generation systems.
CO3	**Explain** the working of different wind power plants.
CO4	**Demonstrate** Ocean and Geothermal energy generation.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	3
CO2	2	2	-	-	-	-	-	-	-	-	-	2	2	3
CO3	2	2	-	-	-	-	-	-	-	-	-	2	2	3
CO4	2	2	-	-	-	-	-	-	-	-	-	2	2	3

UNIT-I

Principle of Renewable Energy: Comparison of renewable and conventional energy sources Ultimate energy sources - natural energy currents on earth - primary supply to end use Spaghetti& Pie diagrams-energy planning-energy efficiency and management. Battery basics, types- Testing, performance of batteries-Fuel cell types, Fuel processing, concept to product.

UNIT-II

Solar Radiation: Extra-terrestrial solar radiation terrestrial solar radiation solar thermal conversion-solar thermal central receiver systems-photo voltaic energy conversion solar cells -models.

UNIT-III

Wind energy: Planetary and local winds - vertical axis and horizontal axis wind mills- principles of wind power-maximum power-actual power-wind turbine operation-electrical generator

UNIT-IV

Energy from Oceans: Ocean temperature differences - principles of OTEC plant operations - wave energy-devices for energy extraction-tides-simple single pool tidal system.

Geothermal energy: Origin and types - Biomass **Bio fuels**: classification - direct combustion for heat and electricity generator-anaerobic digestion for biogas-bio gas digester-power generation. Flywheels and super capacitors.	
Text Books:	1. G.D.Rai , Non-Conventional Energy Sources, Khanna Publications, 6th edition, 1988. 2. BH Khan, Non-Conventional Energy Resources, McGraw Hill Education, 3rd edition, 2016.
References:	1. John Twidell& Toney Weir: Renewable Energy Resources 3rd Edition, 2015. 2. D.P.Kothari, K.C.Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI ,2nd edition 2011 3. Saeed S. Hasan, D.K.Shar, Non-Conventional Energy Resources, Kataria, S. K., & Sons,4th edition 2017
NPTEL Course Links:	1. https://onlinecourses.nptel.ac.in/noc22_ge14/preview 2. https://nptel.ac.in/courses/103103206 3. https://nptel.ac.in/courses/108108078

Electrical Energy Conservation and Auditing

IV B. Tech. – VII Semester (Code: 24EE704/OB)

Lectures	3	Tutorial	0	Practical	0	Credits	3
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basic Mathematics, Power Generation and Transmission, Basic Electrical & Electronics Engineering.

Course Objectives: To make the students

- **Global** and Indian energy scenario, auditing principles &guidance for implementation.
- **Identify** the performance of electrical motors and systems under various conditions.
- **Know** the Performance evaluation techniques of electrical equipment such as motors and lighting system.
- **Usage** of energy conservation in various industrial and financial analysis

Course Outcomes: After completion of this course, Students will be able to

CO1	**Illustrate** Global and Indian energy scenario, Energy management and Auditing principles and effective energy management.
CO2	**Make use** of efficient electrical motors and systems under distinct situations.
CO3	**Develop** lighting system and energy conservation building code for energy saving opportunity.
CO4	**Evaluate** the energy performance and financial feasibility of cogeneration systems using performance tests, numerical analysis, and industrial case studies.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	3	-	-	3	3	-	-	3	1	3	-	-
CO2	3	3	3	-	-	3	1	-	-	3	1	3	-	-
CO3	3	3	3	-	-	2	3	-	-	3	1	3	-	-
CO4	3	2	3	-	-	3	3	-	-	3	1	3	-	-

UNIT-I

Energy scenario-(Primary and secondary energy, commercial energy and non-commercial energy, Renewable and non -renewable energy) Energy, Purchase power parity(PPP), energy conservation; Energy audit-Types and objective; Energy performance; Instruments and metering for energy audit.

UNIT-II

Electrical Motors: Motor- Types, characteristics, efficiency, selection; Energy efficient motors, Factors affecting motor efficiency, rewinding efficiency, speed control, Star labelling

HVAC and Refrigeration system: Psychometrics' and air conditioning process; refrigeration-types, properties, selection, factors affecting performance, performance assessment- split air conditioning.

UNIT-III	
Lighting system: basic parameters and terms in lighting system, light source and lamp types, Illuminance - levels, methods of calculating, general energy saving opportunities, energy efficient lighting controls, lighting case study. **Energy conservation in Building and ECBC**: Energy conservation amendment; Energy conservation building code (ECBC)- Approaches, guidelines on building envelope, heating ventilation, air conditioning system, service hot water, lighting and electrical power.	
UNIT-IV	
Energy Performance systems: Cogeneration systems-purpose of the performance test, terms and definitions, numerical, case study of bottoming cycle cogeneration in a cement industry. **Financial Analysis-** Introduction, fixed and variable costs, interest charges, simple payback period.	
Text Books:	1. Clive Beggs, Energy Management supply and conservation.,Routledge, 2^{nd} Ediition, 2009. 2. Anil kumar, Om Prakash, Prashant singh chauhan, and Samsher gautham. Energy Management conservation and Audits., CRC Press, 1^{st}Edition,2022
References:	1. Sonal Desai. Handbook of energy audit. McGraw Hill Education,1stEdition, 2015 2. Zoran K. Morvay and Dusan Gvozdenac. Applied industrial energy and environment management ,Wiley-IEEE Press,1stEdition,2008 3. Linda Reeder. Guide to green building rating systems.Wiley,1stEdition, 2010.
NPTEL Course Links:	1. NPTEL :: Environmental Sciences- NOC: Basic Principles of Energy Management & Energy Audit 2. NPTEL :: Environment- NOC: Building Energy Systems and Auditing 3. https://onlinecourses.swayam2.ac.in/nou25_es14/preview 4. https://onlinecourses.nptel.ac.in/noc26_ar07/preview

Industrial Electrical Systems

IV B. Tech. – VII Semester (Code: 24EE704/OC)

Lectures	3	Tutorial	0	Practical	0	Credits	3
Continuous Internal Evaluation			40	Semester End Examination			60

Pre-Requisite: Basics of Electrical systems, Basics of mathematics.

Course Objectives: To make the students

- **Explain** the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
- **Discuss** various components of industrial electrical systems
- **Estimate** and select the proper size of various electrical system components.
- **Solve** problems involving with different AC and DC sources in electrical circuits.

Course Outcomes: After completion of this course, Students will be able to

CO1	**Demonstrate** the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
CO2	**Infer** and outline various components of industrial electrical systems.
CO3	**Apply** and analyses the selection the proper size of various electrical system components.
CO4	**Illustrate** and solve problems involving with different AC and DC sources in electrical circuits.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

CO	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	2	-	-	-	-	-	-	-	1	3	2	-
CO2	3	3	2	-	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	-	-	-	-	-	-	-	1	3	2	-
CO4	3	3	2	-	-	-	-	-	-	-	1	3	2	-

UNIT-I

Electrical System Components: LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram(SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.

Residential and Commercial Electrical Systems: Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

UNIT-II	
Illumination Systems: Understanding various terms regarding light,lumen,intensity,candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.	
UNIT-III	
Industrial Electrical Systems I: HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, single line diagram, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.	
UNIT-IV	
Industrial Electrical Systems II: DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks. **Industrial Electrical System Automation:** Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.	
Text Books:	1. J. B. Gupta, A Course in Electrical Installation Estimating and Cost S.K.Kataria & Sons, ISBN-10-9350142791, 2013. 2. K. B. Raina, Electrical Design, Estimating & Costing, New age International 2nd Edition, 2017.
References:	1. Surjit Singh, Electric Estimating and Costing, Dhanpat Rai and Co., ASINB01MZAPVO4, 2016. 2. S.L.Uppal and G.C.Garg, "Electrical Wiring, Estimating & Costing" , Kha publishers, ISBN: 9788174092403, 9788174092403,2008. 3. H.Joshi, Residential, Commercial and Industrial Electrical Systems Equipment and Selection, McGraw Hill Education, ISBN: 0070620962, 2007.
NPTEL Course Links:	1. NPTEL :: Electrical Engineering - NOC: Electricity and Electrical Wiring 2. NPTEL :: Electrical Engineering - NOC: Industrial Automation and Drives 3. NPTEL :: Electrical Engineering - NOC: Electricity & Safety Measures 4. https://onlinecourses.swayam2.ac.in/nou26_ee04/preview 5. https://onlinecourses.swayam2.ac.in/nou25_ee04/preview 6. https://onlinecourses.swayam2.ac.in/nou25_ec01/preview