

**VEERMATA JIJABAI TECHNOLOGICAL
INSTITUTE (VJTI)
MATUNGA, MUMBAI 400 019**
(Autonomous Institute affiliated to University of Mumbai)



Curriculum
(Scheme of Instruction & Evaluation)

For
Undergraduate Programme Leading to
Bachelor of Technology (B. Tech.) Degree
in
Electrical Engineering

**Implemented from the batch admitted in Academic Year 2023-24
[NEP 2020 based Syllabus]**

Program Educational Objectives (PEOs)

Electrical Engineering Graduates will have ability to

- ❖ Face technological challenges in the area of Electrical Engineering and ICT.
- ❖ Demonstrate expertise to articulate and use for problem solving, analysis design and evolution of electrical and electronics devices and systems.
- ❖ Develop leadership, team building and leadership skills.

Program Outcomes (POs)

Engineering Graduates will be able to:

- ❖ **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- ❖ **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- ❖ **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- ❖ **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- ❖ **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- ❖ **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- ❖ **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- ❖ **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- ❖ **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

- ❖ **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- ❖ **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- ❖ **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

Electrical Engineering Graduates will be able to

- ❖ Critically understand the generation, transmission and distribution concepts of Electrical Power Systems and its control.
- ❖ Gain in-depth knowledge to handle/control various electrical machines/drives used in industry.

Credit Framework for UG Programme in Electrical Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester – V

Sr .	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								T A	MST	ESE	
1	R5EE3010T	Power System Analysis	3	0	0	3	3	20	30	50	Electrical
2	R5EE3011T	Power Electronics	3	0	0	3	3	20	30	50	Electrical
3	R5EE3012T	Microprocessor and Microcontrollers	3	0	0	3	3	20	30	50	Electrical
4	R5EE3013T	Control Systems for Electrical Engineers	3	0	0	3	3	20	30	50	Electrical
5	R5EE31XXT	Program Elective –I	3	1	0	4	4	20	30	50	Electrical
6	R5XX32XXT	Multi-disciplinary Minor-III	3	0	0	3	3	20	30	50	Electrical
7	R5EE3010L	Computer-Aided Power System Analysis Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
8	R5EE3011L	Power Electronics Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
9	R5EE3012L	Microprocessor and Microcontrollers Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
10	R5HS3403	Industrial Management and Entrepreneurship	2	0	0	2	2	ISCE: 60		40	Humanities
Total			20	1	6	27	24				

Credit Framework for UG Programme in Electrical Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester – VI

Sr .	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE3015T	Electrical Drives	3	0	0	3	3	20	30	50	Electrical
2	R5EE3016T	Power System Protection	3	0	0	3	3	20	30	50	Electrical
3	R5EE31XXT	Program Elective – II	3	0	0	3	3	20	30	50	Electrical
4	R5EE3017T	Digital Signal Processing	3	1	0	4	4	20	30	50	Electrical
5	R5XX32XX T	Multi-disciplinary Minor-IV	3	0	0	3	3	20	30	50	Electrical
6	R5XX33XX T	Open Elective – I	3	1	0	4	4	20	30	50	Electrical
7	R5HS3404	Innovation and Product Development in Electrical Engineering	2	0	0	2	2	ISCE: 60		40	Humanities
8	R5EE3015L	Electrical Drives Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
9	R5EE31XXL	Program Elective – II Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
Total			20	2	4	26	24				

Program Elective – I (Sem V)

R5EE3101T	Advanced Electronic Devices
R5EE3102T	Renewable Energy Resources
R5EE3103T	Basics of Communication Engineering
R5EE3104T	Applied Linear Algebra

Program Elective – II (Lab; Sem VI)

R5EE3105T	Digital Electronics
R5EE3106T	Wave Theory and Radiating Systems
R5EE3107T	Sensors & Transducers
R5EE3108T	Internet of Things

Program Elective – III (Sem VII)

R5EE4109T	Energy Management and Costing
R5EE4110T	Optimization Techniques
R5EE4111T	Substation Engineering
R5EE4112T	Restructured Power Systems

Program Elective – IV (Lab, Sem VII)

R5EE4113T	Robotics and Automation
R5EE4114T	High Voltage Engineering
R5EE4115T	Applied Digital Signal Processing
R5EE4116T	Advanced Control Systems

Open Elective – (Tutorial, Sem VII)

R5EE4302T	Energy Audit and Management
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List of Exit Courses after completion of Semester V and VI

1. The exit option is available for students who have earned a total of 132 credits at the End of the Sixth Semester.
2. Student who wants to avail of the exit option after the third year have to earn an additional 6-8 credits from the list of courses shown below.
3. These courses students have to complete within summer vacation after 3rd Year.
4. After fulfillment as mentioned in 1 to 3 above, Students can earn B. Voc. or B. Sc. (Tech.) and the same will be issued by the Institute.

List of Exit Courses after completion of Semester V and VI: Electrical Engineering										
Sr.	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
								TA	MST	ESE
1	R5EE3902I	Project	0	0	12	12	6	ISCE :60		40
2	R5EE3907L	Industrial Automation Lab	0	0	4	4	2	ISCE: 60		40
3	R5EE4111T	Substation Engineering	3	1	-	4	4	20	30	50
4	R5EE4020L	Electrical Simulation Lab	0	0	2	2	1	ISCE: 60		40

**Credit Framework for UG Programme in Electrical Engineering (Level 6.0 - B.Tech. In
Electrical Engineering with Multidisciplinary Minor) - Semester – VII**

Sr .	Course Code	Course Name	L	T	P	H r	C r	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE4018T	Advanced Power Systems	3	0	0	3	3	20	30	50	Electrical
2	R5EE41XXT	Program Elective – III	3	1	0	4	4	20	30	50	Electrical
3	R5EE41XXT	Program Elective –IV	3	0	0	3	3	20	30	50	Electrical
4	R5XX42XX T	Multi-disciplinary Minor-V	3	1	0	4	4	20	30	50	Electrical
5	R5XX43XX T	Open Elective – II	3	1	0	4	4	20	30	50	Electrical
6	R5EE4019L	Advanced Power System Simulation Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
7	R5EE41XXL	Program Elective – IV Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
8	R5EE4801P	Project	0	0	8	8	4	ISCE: 60		40	Electrical
Total			15	3	12	30	24				

**Credit Framework for UG Programme in Electrical Engineering (Level 6.0 - B.Tech. In
Electrical Engineering with Multidisciplinary Minor) - Semester – VIII**

Sr .	Course Code	Course Name	L	T	P	H r	C r	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE4701I	Internship	-	-	-	-	12	ISCE: 60		40	Electrical
2	R5EE4014T	Research Methodology (Online)	2	0	0	2	2	20	30	50	Electrical
Total			2	0	0	2	14				

SEMESTER VII SYLLABUS

		B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM - VII		
COURSE CODE	R5EE4018T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	ADVANCED POWER SYSTEMS	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

PREREQUISITE

- Basic Electrical Machines and Power Systems
- Fundamentals of Microgrid Architecture and Renewable Energy Sources
- Basic Programming in Python or MATLAB
- Elementary Statistics and Linear Algebra

COURSE OUTCOMES

Students should be able to:

1. Design and analyse AI-driven energy management and optimal dispatch strategies for microgrids with distributed energy resources.
2. Interpret microgrid architecture and apply AI-based forecasting techniques to predict load and renewable generation for effective day-ahead energy planning.
3. Design and evaluate AI-driven Energy Management System (EMS) strategies for optimal scheduling of battery storage, responsive loads, and distributed energy resources in a microgrid.

COURSE CONTENTS	
MODULE I	AI AND MACHINE LEARNING FOUNDATIONS FOR POWER SYSTEMS
	Overview of AI/ML in smart grids and microgrids: motivation, challenges, and opportunities. Supervised learning: regression and classification for load forecasting and fault detection - Linear/Logistic Regression, Support Vector Machines (SVM), Decision Trees, Random Forests, Gradient Boosting. Unsupervised learning: clustering for demand profiling and DER grouping- K-Means, Gaussian Mixture Models (GMM), Principal Component Analysis (PCA). Neural Networks: Multi-layer Perceptron (MLP), activation functions, back-propagation; Introduction to Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN/LSTM) for sequential power system data. Regularization, bias-variance trade-off, and cross-validation in the context of power system datasets.
MODULE II	MICROGRID FORECASTING AND ENERGY MANAGEMENT SYSTEMS
	Microgrid Architecture, Components: Solar PV, Wind, Battery Energy Storage (BESS), Diesel Generator, Controllable Loads. Operating modes: Grid-connected vs. islanded. Load and Generation Forecasting, Short-term load forecasting (STLF):

	LSTM and Gradient Boosting models for hourly/daily load prediction. Solar and wind generation forecasting: input features (irradiance, temperature, wind speed), model selection, and error metrics. Day-ahead vs. intra-day forecasting: use cases in microgrid dispatch planning. AI-Based Energy Management Systems (EMS) Optimal scheduling of BESS: charge/discharge decisions based on forecasted load and generation. Demand Response (DR): AI for dynamic pricing signals and smart load control. Economic dispatch using ML: minimizing operating cost while meeting load and storage constraints. Rule-based vs. ML-based EMS: comparison with practical trade-offs.
MODULE III	AI APPLICATIONS IN POWER SYSTEM PROTECTION, STABILITY, AND MAINTENANCE
	Fault Detection and Classification, Types of faults in power systems and microgrids. CNN and LSTM-based algorithms for fault detection and classification using current/voltage waveforms. Phasor Measurement Unit (PMU) data analytics for fault location. Voltage Stability and Frequency Regulation, ANN-based voltage stability index prediction. ML-assisted Load Frequency Control (LFC) for frequency regulation. Introduction to Reinforcement Learning for real-time adaptive control (conceptual overview).

TEXT BOOKS

1. Application of Machine Learning and Deep Learning Methods to Power System Problems, Springer, 2021
2. Essentials of Artificial Intelligence, Matt Ginsberg, MK Publishers, 1993, California
3. Microgrids: Theory and Practice (IEEE Press Series on Power and Energy Systems)
4. Forecasting: Principles and Practice (3rd ed) Rob J Hyndman and George Athanasopoulos.

REFERENCE BOOKS

1. Research Papers.

		B. TECH. IN ELECTRICAL ENGINEERING		FINAL YEAR SEM - VII		
COURSE CODE	R5EE4109T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL L HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	ENERGY MANAGEMENT AND COSTING	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

PREREQUISITE

- Fundamental knowledge of electrical and mechanical systems
- Basic concept of energy audit
- Fundamentals of management

COURSE OUTCOMES

Students should be able to:

1. Identify energy-saving opportunities in electrical power distribution and mechanical systems.
2. Implement an energy conservation program for HVAC, pumps, compressors, DGs, Illumination Boilers, Furnaces, etc.
3. Formulate and implement the method of auditing energy.
4. Calculate various energy efficiency and performance parameters for industrial, residential and commercial loads.

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Energy conservation in the compressor, HVAC, refrigeration, fans and blowers, types of pumps, system characteristics, pump curves, EC opportunities, and cooling. Tower, efficient operation, flow control strategies, DG set systems- selection, installation and operational factor, energy saving measures, energy efficiency. Calculations and case studies in thermal utilities such as boilers, steam systems, furnaces, refractors, and the need for and benefits of cogeneration and waste heat recovery. Schemes, case studies.
MODULE II	BASICS OF ENERGY AND ITS LAWS
	Basics of Energy and its various forms: Electricity basics - DC & AC currents, Electricity tariff, Load management and Maximum demand control, Power factor. Material and Energy balance: Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams.
MODULE III	IMPACT OF ENERGY ON THE ENVIRONMENT

	Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features.
MODULE IV	ENERGY AUDIT
	Energy Management & Audit: Definition, Energy audit-need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Benchmarking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

TEXT BOOKS

1. *Energy for a Sustainable World: From the Oil Age to a Sun-Powered Future*, by José Goldemberg, Thomas B. Johansson, A. K. N. Reddy, and Robert H. Williams, Oxford University Press, Reprint Edition, 2012.
2. *A Modeling Approach to Long-Term Demand and Energy Implications*, by J. K. Parikh, Martinus Nijhoff Publishers, 1983. (*Classic reference; still used in research context*)

REFERENCE BOOKS

1. *Energy Efficiency in Thermal Utilities*, Guidebook for the National Certification Examination for Energy Managers and Auditors, Bureau of Energy Efficiency (BEE), Government of India, Latest Edition, 2023.

 B. TECH. IN ELECTRICAL ENGINEERING		FINAL YEAR SEM - VII				
COURSE CODE	R5EE4110T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL L HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	OPTIMIZATION TECHNIQUES	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

PREREQUISITE

- Advanced level of mathematics
- MATLAB Fundamentals
- Probability Theory

COURSE OUTCOMES

Students should be able to:

1. Translate descriptive statements of the design engineering problems into an optimization problem.
2. Apply Analytical and Numerical methods for Single & Multivariate Nonlinear Programming Problems.
3. Apply the Simplex Method for Linear Programming Problems.
4. Apply Exterior Penalty Function Method for Constrained Optimization Techniques for Nonlinear Programming Problems

COURSE CONTENTS	
MODULE I	INTRODUCTION TO OPTIMIZATION:
	Definition and meaning of optimization, need of optimization. Optimization problem formulation: statement of optimization Problem. Terminology: design vector, objective function, objective function surface, design constraints, constraint surface. Classification of optimization problem.
MODULE II	NONLINEAR PROGRAMMING PROBLEMS—CLASSICAL OPTIMIZATION TECHNIQUES AND BASIC CONCEPTS
	Analytical One-dimensional (Single Variable) Unconstrained Optimization: local and global minima, local and global maxima, necessary and sufficient conditions of single optimization with no constraints. Analytical Multi-dimensional (Multivariate) Unconstrained Optimization: necessary and sufficient condition of multivariate Optimization with no constraints. Analytical Multidimensional Optimization with Equality Constraints: Direct Substitution Method, Lagrange Multipliers Method. Analytical Multidimensional Optimization with Inequality Constraints: Kuhn—Tucker Conditions for Solving Multivariable Inequality Constrained Problems.

MODULE III	NUMERICAL METHODS FOR UNCONSTRAINED OPTIMIZATION OF SINGLE VARIABLE & MULTIVARIABLE NONLINEAR PROGRAMMING PROBLEMS
	Distinction between Analytical and Numerical Methods, unimodal and multimodal function. Numerical Methods for Single Variable Nonlinear Programming Problems: Elimination Methods, Unrestricted Search, Interval Halving Method, Fibonacci Search, Golden Section Search Method, Interpolation Methods—Quadratic Interpolation. Numerical Methods for Multivariable Variable Nonlinear Programming Problems: Univariate Method, Hooke—Jeeves Pattern Search Method, Powell's Pattern Search Method, Indirect Search Methods, Cauchy's Steepest Descent Method, Fletcher—Reeves Method, Newton's Method.
MODULE IV	SIMPLEX METHOD FOR LINEAR PROGRAMMING PROBLEMS
	Definition of linear programming problem (LPP), standard form of LPP. Simplex method, Big-M method, two-phase simplex method. Duality in linear programming – standard primal LP problem, dual LP Problem.
MODULE V	CONSTRAINED OPTIMIZATION TECHNIQUES FOR NONLINEAR PROGRAMMING PROBLEMS
	Structure of Constrained Nonlinear Programming Problems. Exterior Penalty Function Method

TEXT BOOKS

1. *Introduction to Optimum Design*, by Jasbir S. Arora, 4th Edition, Academic Press (Elsevier), 2017.
2. *Optimization Concepts and Applications in Engineering*, by Ashok D. Belegundu and Tirupathi R. Chandrupatla, 2nd Edition, Cambridge University Press, 2019.

REFERENCE BOOKS

1. *Engineering Optimization: Theory and Practice*, by S. S. Rao, 4th Edition, New Age International Publishers, Reprint 2014.
2. *Optimization for Engineering Design: Algorithms and Examples*, by Kalyanmoy Deb, Prentice Hall of India, Reprint Edition, 2012.

		B. TECH. IN ELECTRICAL ENGINEERING		FINAL YEAR SEM - VII		
COURSE CODE	R5EE4111T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL L HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	SUBSTATION ENGINEERING	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

PREREQUISITE

- Fundamentals of Engineering drawing
- Fundamentals of power systems
- PLC Programming

COURSE OUTCOMES

Students should be able to:

1. Describe the primary consideration in the process of substation design
2. Outline the working principles of substation switching equipment
3. Explain the different types of bus configurations
4. Design criteria of substation grounding and protection
5. Illustrate the substation communication (SCADA)

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Background, Needs Determination, Budgeting, Financing, Traditional and Innovative Substation Design, Site Acquisition, Design, Construction and Commissioning Process.
MODULE II	HIGH VOLTAGE SWITCHING EQUIPMENT
	Ambient conditions, Disconnect switches, Load Break switches, high-speed grounding switches, power fuses, circuit switches, circuit breakers, and GIS substations.
MODULE III	TYPES OF SUBSTATIONS & BUS/SWITCHING CONFIGURATIONS
	Transmission substation, distribution substation, collector substation, switching substations, gas-insulated substations, air-insulated substations, package substations (PSS), standards used in substation wiring and communication bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, Comparison of configurations. S

MODULE IV	DESIGN OF SUBSTATION GROUNDING AND PROTECTION
	Reasons for substation grounding system, accidental ground circuit, Design criteria Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design equations, selection of conductors, grounding fence, and other design considerations. Lightning stroke protection-lightning parameters, empirical design methods: substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion.
MODULE V	SUBSTATION AUTOMATION AND COMMUNICATIONS
	Introduction, components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment.

TEXTBOOKS

1. *Electrical Power Substation Engineering*, edited by John D. McDonald, 4th Edition, CRC Press, 2017.
2. *Sub-Station Engineering Design & Computer Applications*, by R. S. Dahiya and Vinay Attri, 1st Edition, S. K. Kataria & Sons, Reprint 2018.

REFERENCE BOOKS

1. *Substation Design and Equipment*, by P. S. Satnam and P. V. Gupta, 1st Edition, Dhanpat Rai Publications, Reprint 2013.
2. *Electric Power Distribution Engineering*, by Turan Gönen, 3rd Edition, CRC Press, 2014.

	B. TECH. IN ELECTRICAL ENGINEERING		THIRD YEAR SEM - VII				
COURSE CODE	R5EE4112T	CREDITS ASSIGNED					
		THEORY	TUTORIAL	LAB	TOTAL L HRS	TOTAL CREDITS	
		3	1	-	4	4	
COURSE TITLE	RESTRUCTURED POWER SYSTEMS	EVALUATION SCHEME %WEIGHTAGE					
		TA	MST	ESE	TOTAL		
		20	30	50	100		

PREREQUISITE

- Power system
- Electrical Machine

COURSE OUTCOMES

Students should be able to:

1. Analyse different market structures.
2. Apply basic concepts of economics to power market, different market mechanisms, competition and market power
3. Formulate peculiarities of electricity as a commodity, models for competition and trading in the electricity sector.
4. Justify the need of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO RESTRUCTURING
	Background, overview of the restructured power industry, unbundling of power system players and the associated issues
MODULE II	BASIC CONCEPTS FROM ECONOMICS
	Fundamentals of Markets, Producers and Consumers models, opportunity cost , Demand and supply functions, Market Equilibrium, Pareto Efficiency, Global Welfare and Dead Weight, Time varying prices, Costs, Risk, Type of Markets, Perfect and Imperfect Markets, Monopoly.
MODULE III	MARKETS FOR ELECTRICITY
	Peculiarities of electricity as a commodity, Trading periods, Bilateral or Decentralized Trading, Centralized Trading, Market Clearing Price, Recovering the fixed costs, Gate closure, Settlement Process, Piecewise linear cost curves, Imperfect competition: Bertrand Model and Cournot Model.
MODULE IV	TRANSMISSION NETWORKS AND ELECTRICITY MARKETS

	Decentralized Trading over a Transmission Network, Centralized Trading over a Transmission Network, Unconstrained Transmission, Constrained Transmission, Economic Dispatch, Congestion Surplus, Nodal Pricing/ Locational Marginal Pricing, Mathematical Formulation of Nodal Pricing, Financial Transmission Rights.
MODULE V	ANCILLARY SERVICES
	Definition of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services.

TEXT BOOKS

1. *Fundamentals of Power System Economics*, by Daniel S. Kirschen and Goran Strbac, 2nd Edition, John Wiley & Sons Ltd, 2018.
2. *Making Competition Work in Electricity (Electrical Power Trading)*, by Sally Hunt, Wiley Finance, Reprint Edition, 2002.

REFERENCE BOOKS

1. *Restructured Power Systems: Operation, Trading and Volatility*, by Mohammad Shahidehpour and Muwaffaq Alomoush, Marcel Dekker Inc., 1st Edition, 2001.

	B. TECH. IN ELECTRICAL ENGINEERING	FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4113T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	ROBOTICS AND AUTOMATION	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

Prerequisite

- Signal System
- Control System
- Mechanical Engineering Fundamentals

COURSE OUTCOMES

Students should be able to:

1. Explain the fundamental principles of robotics and automation, including key components, kinematics, and dynamics.
2. Analyze and implement sensors, actuators, and control systems in robotic applications.
3. Develop and program robotic systems using microcontrollers and automation technologies.
4. Apply robotics and automation concepts to real-world problems through projects and emerging technological trends.

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Overview of robotics and automation: history, applications, and future trends; Types of robots: industrial, mobile, humanoid, and autonomous systems; Basic components of robotic systems: sensors, actuators, controllers; Role of electrical engineering in robotics: power systems, signal processing, and control; Kinematics and dynamics: forward and inverse kinematics basics.
MODULE II	SENSORS AND ACTUATORS IN ROBOTICS
	Sensor types: proximity, vision, force/torque, and inertial sensors; Actuators: DC motors, stepper motors, servo motors, and pneumatic systems; Signal conditioning and interfacing with microcontrollers; Selection criteria for sensors and actuators in robotic applications.
MODULE III	CONTROL SYSTEMS FOR ROBOTICS

	State-space representation of robotic systems and control design; Stability analysis and trajectory tracking; Practical examples: motor speed control and position control.
MODULE IV	ROBOT PROGRAMMING AND MICROCONTROLLERS
	Introduction to robot programming: languages (Python, C/C++, ROS); Microcontrollers in robotics: Arduino, Raspberry Pi, and STM32; Programming for sensor integration and actuator control; Real-time operating systems (RTOS) basics for robotics.
MODULE V	AUTOMATION SYSTEMS AND INDUSTRIAL ROBOTICS
	Principles of industrial automation: PLCs, SCADA, and HMIs; Robotic arms in manufacturing: design and operation; Path planning and motion control in industrial robots; Safety standards and human-robot collaboration, AI applications in Robotics.

TEXT BOOKS

1. "Modern Control Systems" by Richard C. Dorf and Robert H. Bishop.
2. "Principles of Robot Motion: Theory, Algorithms, and Implementations" by Howie Choset et al.
3. "Programming Robots with ROS" by Morgan Quigley et al.
4. "Industrial Automation: Hands-On" by Frank Lamb.

REFERENCE BOOKS

1. "Introduction to Robotics: Mechanics and Control" by John J. Craig.
2. "Robotics: Modelling, Planning and Control" by Bruno Siciliano et al.
3. "Sensors and Actuators: Control System Instrumentation" by Clarence W. de Silva.
4. "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers" by Jonathan W. Valvano
5. "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke.

 B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4113L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	ROBOTICS AND AUTOMATION LABORATORY	EVALUATION SCHEME %WEIGHTAGE				
		ISCE		ESE	TOTAL	
		60		40	100	

Prerequisite

- Signal System
- Control System
- Mechanical Engineering Fundamentals
- MATLAB

COURSE OUTCOMES

Students should be able to:

1. Explain the fundamental principles of robotics and automation, including key components, kinematics, and dynamics.
2. Analyze and implement sensors, actuators, and control systems in robotic applications.
3. Develop and program robotic systems using microcontrollers and automation technologies.
4. Apply robotics and automation concepts to real-world problems through projects and emerging technological trends.

LIST OF EXPERIMENTS

1. Introduction to Robot Kinematics: Simulating forward and inverse kinematics in MATLAB.
2. Sensor Integration: Implementing proximity and vision sensors with Arduino.
3. Actuator Control: Controlling DC motors and servos using PWM signals.
4. PID Controller Implementation: Tuning PID parameters for robotic motion control.
5. State-Space Control: Simulating robotic system stability in MATLAB.
6. Robot Programming Basics: Writing and executing Python and C++ programs for ROS-based robots.

7. Industrial Robotics Simulation: Using software like RoboDK to model industrial robots.
8. Project Work: Designing and implementing a small robotic system (e.g., line-following robot, robotic arm, or automation prototype).

 B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM – VII				
COURSE CODE	R5EE4114T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	HIGH VOLTAGE ENGINEERING	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

Prerequisite

- Power System
- Machine
- EMFT

COURSE OUTCOMES

Students should be able to:

1. Analyze breakdown mechanisms in gases, liquids, solids, and vacuum under different conditions.
2. Evaluate high-voltage generation and measurement techniques for practical applications.
3. Apply relevant national and international standards for testing of high-voltage equipment.
4. Utilize numerical techniques like Finite Element Methods for high-voltage engineering applications.

COURSE CONTENTS	
MODULE I	BREAKDOWN OF GASES, LIQUIDS, SOLIDS & VACUUM
	Townsend's theory and Streamer theory of breakdown; Paschen's law and Schumann's formula; Breakdown of air/SF ₆ under uniform field at NTP; Breakdown under extremely non-uniform fields; Various types of insulating liquids, filtration, and purification of oil; Breakdown mechanisms in oil, solids, and vacuum conditions.
MODULE II	GENERATION OF HIGH VOLTAGE
	Cascaded transformer; Resonance transformer; Cockcroft-Walton circuit; Impulse voltage generator.
MODULE III	MEASUREMENT OF HIGH VOLTAGE AND HIGH CURRENTS
	Resistance voltage divider; Capacitance voltage divider; Shunts and Rogowski coil.
MODULE IV	TESTING OF HIGH VOLTAGE EQUIPMENT AS PER RELEVANT STANDARDS
	Overview of national and international standards; High voltage testing of transformers: power frequency withstand test, induced overvoltage test, impulse voltage test, partial discharge measurement; Testing of cables AC high voltage test, DC high voltage test, tan delta measurement; Testing of surge arresters (IEC 60099);

	Testing of circuit breakers and switchgear (IEC 62271); Testing of insulation systems: insulation resistance, dielectric strength, and dissipation factor; High voltage testing of bushings (IEC 60137); Safety regulations and precautions during high voltage testing; Test report preparation and acceptance criteria as per standards.
MODULE V	PARTIAL DISCHARGE
	Partial discharge and its measurement; Testing for partial discharge in transformers; Importance of impedance matching.
MODULE VI	INTRODUCTION TO FINITE ELEMENT METHODS
	Methods based on Finite Differences and Integral Formulations; The Finite Element Method; 2D Finite Element Modeling of single-phase transformer, solenoid, inductor, capacitors, wire-wound resistor, and toroid.

TEXT BOOKS

1. “High Voltage Engineering”, by M. S. Naidu and V. Kamaraju, Tata McGraw-Hill Education, 2004.
2. “High Voltage Engineering”, by C. L. Wadhwa, 3rd Edition, New Age Publication, 2012.

REFERENCE BOOKS

1. “High Voltage Engineering: Fundamentals”, by W.S. Zaengl and E. Kuffel, Elsevier, 2000.
2. “High Voltage and Electrical Insulation Engineering”, by Wolfgang Mosch and Ravindra Arora, Wiley-IEEE Press, 2011.

	B. TECH. IN ELECTRICAL ENGINEERING	FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4114L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	HIGH VOLTAGE ENGINEERING LABORATORY	EVALUATION SCHEME %WEIGHTAGE				
		ISCE		ESE	TOTAL	
		60		40	100	

Prerequisite

- Power System
- Machine
- EMFT
- MATLAB

COURSE OUTCOMES

Students should be able to:

1. Interpret electric field pattern between different electrode surfaces.
2. Evaluate breakdown of air using different electrode system modeling.
3. Apply FEMM modeling on different elements and equipment of high voltage.
4. Evaluate breakdown in transformer oil.

LIST OF EXPERIMENTS

1. To observe electric fields between parallel plates with two different dielectric keeping the gap length 1cm, 5cm, 10cm and applying the potential at 50kV, 200kV, and 600kV.
2. To observe electric field pattern between electrode and plate electrode.
3. To observe electric field pattern between two pointed electrodes.
4. To observe electric field pattern between
 - i. two pointed electrodes and spherical electrode
 - ii. pointed electrodes and spherical electrode grounded
 - iii. spherical electrode at high voltage
 - iv. two spherical electrodes.
5. Transformer oil break down.
6. Lightning Impulse test.
7. Breakdown of air in pointed electrode system.
8. Breakdown of air in spherical electrode system.

9. Tracking in rubber shut.
10. Finite Element Method Magnetics (FEMM) modelling of Single phase transformer, Solenoid, Inductor, Capacitors, wire wound Resistor & Toroid.

		B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM - VII		
COURSE CODE	R5EE4115T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	APPLIED DIGITAL SIGNAL PROCESSING	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

Prerequisite

- Digital Electronics
- DSP
- Signal Processing

COURSE OUTCOMES

Students should be able to:

1. Apply multirate DSP for applications and design efficient digital filters & construct multi-channel filter banks.
2. Select linear filtering techniques to engineering problems.
3. Able to analyze forward and backward linear prediction of a stationary random process using Levinson-Durbin Algorithm.
4. Able to understand and analyze adaptive filters and its application using LMS algorithm & RLS algorithm.

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Overview of Discrete-Time LTI systems, Fourier representation of Discrete-Time Signals and z-transform. Techniques to compute inverse z-transform. Discrete Fourier Transform (DFT) and computation of DFT using Fast Fourier Transform (FFT).
MODULE II	SIGNAL MODELING
	Pade Approximation, Prony's method and Shanks' method. Stochastic models: Autoregressive (AR), Moving Average (MA) and Autoregressive Moving Average models (ARMA). Linear Prediction: forward and backward linear prediction, solutions of the normal equations (Levinson-Durbin algorithm). Power Spectrum Estimation: Parametric and non-parametric methods.
MODULE III	MULTIRATE DIGITAL SIGNAL PROCESSING

	Fundamentals of Multirate systems, Basic multirate operations, Decimation, interpolation, filter design and implementation of sampling rate conversion, polyphase filter structures, time variant filter, structures, multistage implementation of sampling rate conversion of BP signals, sampling rate conversion by an arbitrary factor, interconnection of building blocks, polyphase representation, multistage implementations.
MODULE IV	WAVELET TRANSFORM
	Introduction to wavelets, wavelets and wavelet expansion systems, discrete wavelet transform, multiresolution formulation of wavelet systems, HaarWavelet and other wavelet representations, scaling function, wavelet functions.
MODULE V	MULTIRATE FILTER BANKS
	Maximally decimated filter banks, errors created in QMF banks, simple alias free QMF system, power symmetric filter banks, M channel filter banks, polyphase representation, PR systems, alias free filter banks, Linear phase PR QMF banks, Wavelet transform and its relation to multirate filter banks. Applications of multirate signals processing narrowband LPF, subband coding of speech.

TEXT BOOKS

1. V. Oppenheim and R. W. Schaffer, Discrete Time Signal Processing, Pearson Education, 2000.
2. J. G. Proakis and D. J. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, PHI, 4th Edition, 2007.
3. Introduction to Wavelets and Wavelet Transform: C. S. Burrus, Ramesh and A. Gopinath, Prentice Hall Inc. 1998.
4. Multirate Systems and Filter Banks: P. P. Vaidyanathan, PH International, Englewood Cliffs, New Jersey, 1993.

REFERENCE BOOKS

1. Wavelet Tour of Signal Processing, Stephane Mallat, Academic Press, 1999
2. J. R. Johnson, Introduction to Digital Signal Processing, PHI, 1989.
3. S. K. Mitra, Digital Signal Processing-A Computer Based Approach, MGH, 1997.

	B. TECH. IN ELECTRICAL ENGINEERING	FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4115L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	APPLIED DIGITAL SIGNAL PROCESSING LABORATORY	EVALUATION SCHEME %WEIGHTAGE				
		ISCE		ESE	TOTAL	
		60		40	100	

Prerequisite

- Digital Electronics
- DSP
- Signal Processing
- MATLAB

COURSE OUTCOMES

Students should be able to:

1. Analyze discrete-time LTI systems using Fourier and z-transform techniques and compute inverse z-transforms for system characterization.
2. Model signals using Pade Approximation, Prony's method, stochastic models (AR, MA, ARMA), and estimate power spectra using parametric and non-parametric methods.
3. Implement multirate signal processing operations such as decimation, interpolation, polyphase structures, and multistage sampling rate conversion.
4. Apply wavelet transform and filter bank techniques for signal decomposition and reconstruction in practical signal processing applications.

LIST OF EXPERIMENTS

1. Generation and visualization of discrete-time signals. (MATLAB/Python)
2. Linear and circular convolution of signals. (MATLAB/Python)
3. Computation of Discrete Fourier Transform (DFT) and Inverse DFT. (MATLAB/Python)
4. Fast Fourier Transform (FFT) and its applications. (MATLAB/Python)
5. Computation of z-transform and inverse z-transform. (MATLAB/Python)
6. Signal modeling using Prony's method and AR/MA/ARMA models. (MATLAB/Python)
7. Implementation of decimation and interpolation. (MATLAB/Python/DSP Processor)
8. Computation of Discrete Wavelet Transform (DWT). (MATLAB/Python)
9. Design and implementation of multirate filter banks. (MATLAB/Python/DSP Processor)
10. Real-time FIR and IIR filtering on DSP hardware. (DSP Processor)

 B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4116T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	ADVANCED CONTROL SYSTEMS	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

Prerequisite

- Control System
- Signal System
- Signal Processing

COURSE OUTCOMES

Students should be able to:

1. Design passive as well as active compensators using root locus design techniques.
2. Design Lag, lead & Lag-lead compensators using frequency response techniques.
3. Design Controllers & Observers using State-space design techniques.
4. Analyse Digital Control Systems using z-transform
5. Understand the fundamentals of Nonlinear Systems.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO CONTROLLER DESIGN
	Analysis & Design Objectives, An Outline of Control System Design. A review of P, PI and PID Controllers.
MODULE II	DESIGN VIA ROOT LOCUS TECHNIQUES
	Transient Response Design via Gain Adjustment, Improving Steady State Error via Cascade Compensation, Improving Transient Response via Cascade Compensation, Improving Steady State and Transient Response. Introduction to various controllers and their steady state errors.
MODULE III	DESIGN VIA FREQUENCY RESPONSE
	Transient Response via Gain Adjustment, Lag Compensation, Lead Compensation, Lag- Lead Compensation.
MODULE IV	DESIGN VIA STATE SPACE

	Controller Design, Controllability, Alternative Approaches to Controller Design, Observer Design, Observability, Alternative Approaches to Observer Design, Steady-State Error Design via Integral Control.
MODULE V	DIGITAL CONTROL SYSTEM
	Introduction, The Z-Transform, Transfer Function, Block Diagram Reduction, Stability, Steady-State Errors.
MODULE VI	INTRODUCTION TO NONLINEAR SYSTEMS
	Introduction to Nonlinear models and nonlinear phenomena, Modelling of a Simple Pendulum, Phase curves and Phase velocity vector field, equilibrium points, existence of periodic orbits, Bifurcation.

TEXT BOOKS

1. Control System Engineering, Norman Nise, Fourth Edition. Wiley International Edition.
2. Modern Control System Theory", M. Gopal, Wiley Eastern Ltd., New Delhi.
3. Hassan K Khalil, Nonlinear Systems, 2nd Edition, Prentice Hall.

REFERENCE BOOKS

1. Control Engineering: An introductory course, J. Wilkie, M. Johnson & R. Katebi, 1st edition, Palgrave.
2. M. Vidyasagar, Nonlinear Systems Analysis, Prentice Hall, Englewood Cliffs, New Jersey, second edition, 1993

	B. TECH. IN ELECTRICAL ENGINEERING	FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4116L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	ADVANCED CONTROL SYSTEMS LABORATORY	EVALUATION SCHEME %WEIGHTAGE				
		ISCE		ESE	TOTAL	
		60		40	100	

PREREQUISITE

- Control System
- Signal System
- Signal Processing

COURSE OUTCOMES

Students should be able to:

1. Convert transfer functions to state-space models, analyze first- and second-order system responses, and assess system behavior using MATLAB.
2. Perform root locus, Bode plot, and polar plot analysis to determine stability, gain/phase margins, and frequency response characteristics.
3. Implement and analyze P, PI, PD, and PID controllers, studying their effects on transient and steady-state performance.
4. Verify controllability and observability, analyze discrete-time system responses, and simulate nonlinear system behavior using phase portraits.

LIST OF EXPERIMENTS

1. To study conversion of transfer function to state space model (SSM) and obtain a solution of the state equation.
2. To study the response of first order systems.
3. To study the step response of different types of second order systems.
4. To perform stability analysis using the root locus method.
5. To perform frequency response analysis by obtaining polar plots and Bode plots from MATLAB.
6. To study and analyze the operation of a Proportional Controller.
7. To study and analyze the operation of Proportional-Integration (PI) Controller.
8. To study and analyze the operation of Proportional-Derivative (PD) Controller.
9. To study and analyze the operation of Proportional-Integration-Derivative (PID) Controller.
10. To check controllability and observability of systems using MATLAB.
11. To Analyze the step response of discrete-time systems.
12. To simulate and plot phase portraits for a nonlinear system.

 B. TECH. IN ELECTRICAL ENGINEERING		FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4302T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	ENERGY AUDIT AND MANAGEMENT	EVALUATION SCHEME %WEIGHTAGE				
		TA	MST	ESE	TOTAL	
		20	30	50	100	

COURSE OUTCOMES

Students should be able to:

1. Analyze the principles of energy auditing, energy conservation techniques, and energy management strategies for industrial and commercial applications.
2. Evaluate the performance of electrical and thermal energy systems and identify energy-saving opportunities using appropriate audit methodologies.
3. Assess the environmental and economic impacts of energy consumption and recommend sustainable energy practices.
4. Apply energy efficiency techniques, demand-side management strategies, and renewable energy integration to optimize energy use in various sectors.

COURSE CONTENTS	
MODULE I	FUNDAMENTALS OF ENERGY AUDIT AND ENERGY MANAGEMENT
	General principles of energy management and energy audit; Need and benefits of energy conservation; Types of energy audits: Preliminary, detailed, and investment-grade audits; Energy audit methodology: Data collection, analysis, and reporting; Energy audit instruments and measurement techniques; Case studies on energy audit implementation in industries.
MODULE II	ELECTRICAL ENERGY MANAGEMENT AND CONSERVATION
	Electrical energy assessment techniques; Load management and demand-side management; Power quality issues and their impact on energy consumption; Energy-efficient lighting systems and practices; Energy efficiency in motors, drives, and transformers; Case studies on electrical energy savings in industrial and commercial setups.
MODULE III	RENEWABLE ENERGY AND SUSTAINABLE ENERGY PRACTICES
	Overview of renewable energy sources: Solar, wind, biomass, and geothermal; Integration of renewable energy in industrial and commercial sectors; Hybrid energy systems and microgrids; Economic and environmental benefits of renewable energy adoption; Government policies and incentives for renewable energy projects; Case studies on renewable energy implementation in industries.

MODULE IV	ENERGY ECONOMICS AND POLICY FRAMEWORK
	Energy economics: Life cycle cost analysis and payback period; Financial analysis for energy efficiency projects: Cost-benefit analysis, Net Present Value (NPV), Internal Rate of Return (IRR); Energy performance contracting and ESCO (Energy Service Company) model; National and international energy policies and regulations; ISO 50001 Energy Management System (EnMS); Case studies on energy efficiency financing and policy-driven energy projects.

TEXT BOOKS

1. "Guide to Energy Management" – Barney L. Capehart, Wayne C. Turner, and William J. Kennedy.
2. "Handbook of Energy Audit" – Albert Thumann and William J. Younger.
3. "Industrial Energy Management: Principles and Applications" – Giuseppe Anzaldo, Victor J. Gonzalez, and Jorge Morales.

REFERENCE BOOKS

1. "Energy Audit and Management" – TERI (The Energy and Resources Institute).

	B. TECH. IN ELECTRICAL ENGINEERING	FOURTH YEAR SEM - VII				
COURSE CODE	R5EE4019L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	ADVANCED POWER SYSTEM SIMULATION LABORATORY	EVALUATION SCHEME %WEIGHTAGE				
		ISCE		ESE	TOTAL	
		60		40	100	

COURSE OUTCOMES

Students should be able to:

1. Develop and implement ANN/ML models for load and renewable generation forecasting and state estimation in microgrids.
2. Design AI-driven Energy Management System (EMS) strategies and apply ANN/ML for load frequency and voltage stability control.
3. Apply clustering and data analytics techniques using ANN/ML to profile loads and optimize microgrid operation.

LIST OF EXPERIMENTS

1. Short-Term Load Forecasting using ANN/ML models
2. Solar and Wind Generation Forecasting using ANN/ML models
3. AI-Based Energy Management System: Optimal Battery Scheduling and Load Control
4. Load Frequency Control using ANN/ML models
5. Clustering and Demand Profiling using K-Means, GMM, or PCA
6. Fault Detection and Classification using CNN/LSTM
7. Voltage Stability Assessment using ANN
8. Comparative Study of ML Models for Forecasting and EMS Applications
9. Load Flow analysis of SMIB using Professional Software (POWERWORLD).
10. Transient stability analysis of SMIB system.
11. Load flow analysis of multi-machine systems.
12. Transient stability analysis of multi-machine systems.
13. Contingency analysis using Professional Software (POWER WORLD).

 B. TECH. IN ELECTRICAL ENGINEERING		SECOND YEAR SEM- VII				
COURSE CODE		CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		2	-	-	2	2
COURSE TITLE	SOCIO-ECONOMIC IMPACT OF EV	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite:

1. Basic knowledge of electrical engineering fundamentals, energy systems, and environmental science.
2. Understanding of basic economics, including cost analysis and resource utilization.
3. Familiarity with conventional automobile systems and elementary engineering mathematics is desirable.

COURSE OUTCOMES

Students should be able to:

1. Assess the economic feasibility and environmental benefits of EV adoption by analyzing case studies, charging infrastructure requirements, and future market trends.
2. Analyze the economic aspects of electric vehicles, including purchase cost, operating cost, lifecycle cost, and total cost of ownership compared with conventional vehicles..
3. Evaluate the environmental impacts of electric vehicles by assessing greenhouse gas emissions, energy efficiency, carbon footprint, and sustainability throughout the vehicle life cycle.
4. understand the role of electric vehicles in promoting sustainable transportation through renewable energy integration, emission reduction strategies, and government policies and incentives.

COURSE CONTENTS	
MODULE I	EV infrastructure & Impacts on power system
	An Overview of EV Charging Infrastructure, Domestic charging infrastructure, public charging infrastructure: categories of charging stations, Normal, Occasional, Fast, battery swapping, Move-and-charge zones, Payment systems. Impacts on power system: Harmonic impact, Harmonic compensation, Current demand impact, Current demand minimization. Energy diversification and

	efficiency.
MODULE II	Vehicular Safety and Government norms
	Road and Automotive Safety Systems: Active and passive safety, Safety Regulations for vehicular application, occupant protection, Traffic signs, traffic rules. Government Norms, Regulations and Policies: Motor vehicle act: control of transport, RTO and other regulations, offences, penalties and procedures.
MODULE III	Environment and Economy
	Transportation pollution, Environment-sound EVs, Economy. Multi-Stakeholder Governance of EV Charging. Assessing Charging Demand and Setting Targets, Location Planning and Land Allocation. reductions in greenhouse gas emissions and pollution. economic impact, including job creation in the EV industry, changes in the automotive market, and the effects on oil dependency.
MODULE IV	Electric Vehicle (EV) Policies
	Goal of EV30@30 campaign. Goals of electric vehicles initiative in India. National Electric Mobility Mission Plan (NEMMP): Objectives, Steps taken by Indian Government for faster adoption of electric vehicles, Barriers to adoption of electric mobility, E-mobility strategy, NEMMP Implementation structure. Maharashtra Electric Vehicle Policy, 2021: Objectives, Basic demand incentives for electric vehicles, Vehicle segment-wise scrappage incentives, Incentives for charging infrastructure.

TEXT BOOKS

1. Web link: <https://emobility.araiindia.com/standards>.
2. . Chan, C.C. and Chau, K.T., (2001), “Modern Electric Vehicle Technology,” Oxford University Press, ISBN: 9780198504160
3. Handbook of Electric Vehicle Charging Infrastructure Implementation, Version-1, prepared by NITI Aayog, Ministry of Power (MoP), Department of Science and Technology, Bureau of Energy Efficiency, WRI India.

REFERENCE BOOKS

1. Weine Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Third Edition, Mehrdad Ehsani Yimin Gao Stefano Longo Kambiz M. Ebrahimi.
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi