Zeal Education Society's

ZEAL COLLEGE OF ENGINEERING & RESEARCH, PUNE – 41

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

*NBA Accredited, NAAC Accredited with **A**+ Grade / ISO 21001:2018*

DEPARTMENT OF ELECTRICAL ENGINEERING

Curriculum Structure and Syllabus of

S.Y. B. Tech. – Electrical Engineering

(With effect from - Academic Year 2026- 27)

(Honors Course)

VISION OF THE INSTITUTE

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude.

MISSION OF THE INSTITUTE

- To achieve academic excellence through innovative teaching and learning process.
- To imbibe the research culture for addressing industry and societal needs.
- To inculcate social attitude through community engagement initiatives.
- To provide conducive environment for building the entrepreneurial skills.

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION:

To be premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude.

MISSION:

M1: To achieve academic excellence through innovative teaching and learning process
M2: To imbibe the research culture for addressing industry and societal needs.
M3: To inculcate social attitude through community engagement initiatives.
M4: To provide conducive environment for building the entrepreneurial skills.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

PEO1: Graduates will be able to apply their technical skill sets and knowledge to solve engineering-based problems in industry, academic and diverse fields of Electrical Engineering.
PEO2: Graduates will demonstrate ethical and social responsibility while engaging in research, innovative practices and entrepreneurial activities, contributing positively to society and technological advancement.
PEO3: Graduates will embrace lifelong learning and adaptability, staying updated with emerging technologies, industry trends and advancements in electrical engineering.

PROGRAM OUTCOMES (POs):

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop the solution of complex engineering problems.
PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6).

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PO6: The Engineer and the World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9).

PO8: Individual and Collaborative Team Work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO1: To apply knowledge to build ability to design analyses and solve problems in the field of electrical engineering through power systems, electrical machines, control systems, electronics and automation.

PSO2: To develop solution to real time problems through appropriate techniques, modern engineering hardware and software tools related Electrical engineering.

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LIST OF ABBREVIATIONS

Abbreviation	Description
BSC	Basic Science Course
ESC	Engineering Science Course
PCC	Program Core Course
PEC	Program Elective Course
MDM	Multidisciplinary Minor
OE	Open Elective - Other than a particular program
VSEC	Vocational and Skill Enhancement Course
AEC	Ability Enhancement Course
ENTR	Entrepreneurship
EC	Economics
MC	Management Courses
IKS	Indian Knowledge System
VEC	Value Education Courses
RM	Research Methodology
CEP	Community Engagement Project
FP	Field Project
PROJ	Project
INT	Internship
OJT	On Job Training
CC	Co-curricular Courses
HSSM	Humanities Social Science and Management
ELC	Experiential Learning Course
B. Tech	Bachelor of Technology
L	Lecture
P	Practical
T	Tutorial
H	Hours
CR	Credits
CIE	Continuous Internal Evaluation
ETE	End Term Evaluation
TW	Term Work
OR	Oral
PR	Project

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B. Tech. with Honours – Electrical Engineering

Electric Vehicle Honours Courses

Course Code	Course Type	Course Name	Teaching Scheme (hrs/Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
EEHC311	Hon	Fundamentals of Electric Vehicle	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC412	Hon	Energy Storage Systems for Electric Vehicles	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC513	Hon	Power Electronics for Electric Vehicles	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC614	Hon	Electric Motors and Drives for EVs	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC715	Hon	Condition Monitoring & Predictive Maintenance in EV	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC816	Hon	Electric Vehicle Charging Infrastructure	3	-	-	3	3	-	3	-	100	-	-	-	100

Power System Honours Courses

Course Code	Course Type	Course Name	Teaching Scheme (hrs/Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
EEHC321	Hon	Energy Management Systems and Sustainable Power Systems	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC422	Hon	Artificial Intelligence Technology in Power System	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC523	Hon	Optimization Techniques for Power System Operation and Planning	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC624	Hon	Renewable Energy Integration in Power Systems	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC725	Hon	Artificial Intelligence for Smart Grids and Microgrids	3	-	-	3	3	-	3	-	100	-	-	-	100
EEHC826	Hon	Cybersecurity of Power Systems	3	-	-	3	3	-	3	-	100	-	-	-	100

BoS Chairman

ZES's Zeal College of Engineering & Research PU/PN/Engg./285/2007 Narhe, Pune-41

Director
ZES's Zeal College of Engineering & Research Narhe, Pune - 411041.

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9	EEHC523	Optimization Techniques for Power System Operation and Planning	
10	EEHC624	Renewable Energy Integration in Power Systems	
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12	EEHC826	Cybersecurity of Power Systems	

SYLLABUS

Electric Vehicle Honours Course

DEPARTMENT OF ELECTRICAL ENGINEERING

Program: B. Tech. with Honours (Electrical Engineering)							**Semester: III**		
Course: Fundamentals of Electric Vehicle							**Code:** EEHC311		
Teaching Scheme (Hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
3			3		100				100

Prerequisites:

Basic knowledge of Electrical Engineering, electrical machines, power electronics, batteries and fundamental concepts of automobiles.

Course Objectives:

To introduce students to the fundamental concepts of electric vehicles, including vehicle architecture, electric propulsion systems, energy storage, power electronics, charging infrastructure, and emerging trends in electric mobility for sustainable transportation.

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

CO1	Explain the basic architecture, classification and working principles of electric vehicles.
CO2	Describe the construction, working and characteristics of electric motors used in electric vehicles.
CO3	Explain the types, characteristics and management of batteries and energy storage systems used in EVs.
CO4	Compare conventional and electric vehicles and discuss emerging trends and challenges in electric mobility.

Course Contents:

Unit	**Description**	**Duration (Hrs.)**
1.	**Introduction to Electric Vehicles:** History and evolution of electric vehicles; Need for electric mobility; Classification of electric vehicles – Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV); Comparison of conventional ICE vehicles and electric vehicles; Basic architecture of electric vehicles; Vehicle dynamics – tractive effort, rolling resistance, aerodynamic drag, grading resistance; Advantages, limitations and challenges of electric vehicles.	10
2.	**Electric Propulsion Systems:** Requirements of electric motors for EV applications; Types of traction motors – DC motors, Induction motors, Permanent Magnet Synchronous Motor (PMSM), Brushless DC Motor (BLDC), Switched Reluctance Motor (SRM); Construction, working principle and characteristics of traction motors; Comparison of different motors for EV applications; Motor selection criteria; Basic concept of regenerative braking.	10
3.	**Energy Storage Systems for Electric Vehicles:** Importance of energy storage in EVs; Types of batteries – Lead-acid, Nickel-based, Lithium-ion, Solid-state batteries; Battery parameters – Capacity, C-rate, State of Charge (SOC), State of Health (SOH), Depth of Discharge (DoD), Energy density, Power density, Cycle life; Battery Management System (BMS) – functions and importance; Thermal management of batteries; Introduction to ultracapacitors and fuel cells as alternative energy storage.	12
4.	**Hybrid Electric Vehicles, Performance and Future Trends:** Architecture of Hybrid Electric Vehicles – Series, Parallel and Series-Parallel configurations; Operating modes of HEVs; Performance parameters of electric vehicles	12

	– Range, Energy consumption, Efficiency; Environmental and economic benefits of EVs; Policies and incentives for EV adoption in India; Emerging trends – Autonomous EVs, Connected vehicles, Solid-state batteries, Wireless charging; Challenges and future scope of electric mobility.	
	TOTAL	**42**

Text Books:

1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
2. Chris Mi, M. Abul Masrur and David Wenzhong Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley.
3. Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press.
4. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley.

Reference Books:

1. John G. Hayes and G. Abas Goodarzi, *Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles*, Wiley.
2. Seth Leitman and Bob Brant, *Build Your Own Electric Vehicle*, McGraw-Hill.
3. Hybrid Electric Vehicle System Modeling and Control – Wei Liu, Wiley.
4. Electric Vehicle Machines and Drives: Design, Analysis and Application – K. T. Chau, Wiley.

E-Resources:

1. NPTEL Course: Electric Vehicles – Part 1 – Prof. Amit Jain, IIT Delhi https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ee01
2. NPTEL Course: Fundamentals of Electric Vehicles – Prof. B. G. Fernandes / related IIT courses https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ee99
3. NPTEL Course: Advanced Electric Drives – Prof. Shyama Prasad Das, IIT Kanpur https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_ee94
4. ARAI / Ministry of Heavy Industries – EV related standards and guidelines

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Program: B. Tech. with Honours (Electrical Engineering)							**Semester: IV**		
Course: Energy Storage Systems for Electric Vehicles							**Code:** EEHC412		
Teaching Scheme (Hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
3			3		100				100

Prerequisites:

Basic knowledge of Electrical Engineering, electrochemistry, batteries, power electronics and fundamentals of electric vehicles.

Course Objectives:

To provide students with a comprehensive understanding of energy storage technologies used in electric vehicles, including battery systems, battery management, thermal management, alternative storage technologies, and their integration with electric vehicle powertrains for efficient and safe operation.

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

CO1	Explain the fundamental requirements and performance parameters of energy storage systems for electric vehicles.
CO2	Describe the construction, working principles and characteristics of different battery technologies used in EVs.
CO3	Explain the functions and architecture of Battery Management Systems (BMS) for safe and efficient battery operation.
CO4	Analyze the integration of energy storage systems with electric vehicle powertrain and charging systems.

Course Contents:

Unit	**Description**	**Duration (Hrs.)**
1.	**Introduction to Energy Storage Systems for EVs:** Role of energy storage in electric vehicles; Requirements of energy storage systems for EV applications; Key performance parameters – Energy density, Power density, Specific energy, Specific power, Cycle life, Efficiency, Cost, Safety and Environmental impact; Comparison of energy storage requirements for BEV, HEV and PHEV; Overview of energy storage technologies used in electric mobility.	10
2.	**Battery Technologies for Electric Vehicles:** Fundamentals of electrochemical cells; Primary and secondary batteries; Construction, working principle and characteristics of Lead-acid, Nickel-Cadmium (Ni-Cd), Nickel-Metal Hydride (Ni-MH) and Lithium-ion batteries; Types of Lithium-ion chemistries (LCO, LFP, NMC, NCA, LTO); Emerging battery technologies – Solid-state batteries, Lithium-sulphur and Lithium-air batteries; Comparison of battery technologies for EV applications.	10
3.	**Battery Management System (BMS):** Need and importance of BMS in electric vehicles; Functions of BMS – Monitoring, Protection, Balancing, SOC/SOH estimation and Communication; Architecture of BMS (Centralized, Modular and Distributed); Cell balancing techniques – Passive and Active balancing; Protection against over-voltage, under-voltage, over-current, short-circuit and over-temperature; Communication protocols used in BMS.	12

4.	**Alternative Energy Storage and System Integration:** Ultracapacitors (Supercapacitors) – Construction, characteristics and applications in EVs; Hybrid energy storage systems (Battery + Ultracapacitor); Flywheel energy storage – Basic principle and applications; Fuel cells for electric vehicles – Types, working and hydrogen storage; Integration of energy storage with electric powertrain; On-board energy management strategies; Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) concepts; Future trends in EV energy storage technologies.	12
	TOTAL	**42**

Text Books:

1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
2. Chris Mi and M. Abul Masrur, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley.
3. John G. Hayes and G. Abas Goodarzi, *Electric Powertrain*, Wiley.
4. Mehrdad Ehsani et al., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press.

Reference Books:

1. Thomas B. Reddy, *Linden's Handbook of Batteries*, McGraw-Hill.
2. Gregory L. Plett, *Battery Management Systems – Volume I & II*, Artech House.
3. Bruno Scrosati, *Advances in Battery Technologies for Electric Vehicles*, Elsevier.
4. K. T. Chau, *Energy Systems for Electric and Hybrid Vehicles*, IET.

E-Resources:

1. NPTEL Course: Electric Vehicles – Part 1 & Part 2 https://nptel.ac.in/courses/108106170
2. NPTEL Course: Advanced Electric Drives https://nptel.ac.in/courses/108104011
3. NPTEL / SWAYAM courses on Battery Management Systems and Energy Storage https://nptel.ac.in/courses/113105102
4. ARAI, SAE and IEC standards related to EV batteries and safety

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SYLLABUS

Power System Honours Course

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Program: B. Tech. with Honours (Electrical Engineering)							**Semester: III**		
Course: Energy Management and Sustainability in Power System							**Code:** EEHC321		
Teaching Scheme (Hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
3			3		100				100

Prerequisites:

Basic knowledge of Electrical Engineering, electrical circuits, electrical power and energy, and conventional and renewable energy sources.

Course Objectives:

To introduce students to the fundamental concepts of energy management and sustainable power systems, and to develop an understanding of renewable-energy integration, energy storage, energy management systems, smart grids, energy economics and emerging sustainable energy technologies.

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

CO1	Explain the basic concepts of energy management, energy efficiency and sustainability in electrical power systems.
CO2	Describe the principles of sustainable power generation and the basic factors involved in sustainable power-system planning.
CO3	Describe the basic functions of Energy Management Systems, smart grids and demand-response techniques for efficient energy management.
CO4	Compare basic economic and environmental aspects of conventional and sustainable energy systems and explain emerging technologies for future power systems.

Course Contents:

Unit	**Description**	**Duration (Hrs.)**
1.	**Fundamentals of Energy Management and Sustainable Power Systems:** Global and Indian energy scenario; conventional and renewable energy resources; electricity generation and consumption; need for sustainable energy systems; basic concept, objectives and importance of energy management; energy management at generation, transmission, distribution and consumer levels; energy conservation and energy efficiency; basic electrical load concepts including load profile, maximum demand, average demand, load factor and diversity factor; peak-demand management and load shifting; efficient utilization of electrical energy; basic concepts of energy security, energy access and sustainability; introduction to the role of digital technologies in energy monitoring and management.	10
2.	**Sustainable Power Generation and Power-System Planning:** Concept and need for sustainable power generation; basic principles of sustainable energy systems; comparison of conventional and renewable power generation from the sustainability point of view; technical, economic and environmental aspects of power generation; concept of sustainable generation mix and energy transition; introduction to distributed generation; environmental effects of electricity generation; basic concepts of carbon emissions and carbon intensity; need for sustainable power-system planning; basic concepts of reliability and availability of power supply; introduction to economical operation of power-generation systems; and simple case studies of sustainable power-generation systems.	10

3.	**Energy Management System, Smart Grid and Demand Response:** Introduction to Energy Management System (EMS) and its importance in power systems; basic objectives and functions of EMS; simple EMS architecture; introduction to SCADA and its role in power-system monitoring; basic concepts of measurement, data acquisition and real-time monitoring; introduction to Remote Terminal Units (RTUs) and Intelligent Electronic Devices (IEDs); basic applications of EMS; introduction to load forecasting and its importance; basic concept of generation scheduling; concept and need for smart grid; basic features of smart grid; introduction to Demand Side Management (DSM) and Demand Response (DR); basic demand-response methods; peak clipping, valley filling and load shifting; and introduction to prosumers and Distributed Energy Resources in modern energy systems.	12
4.	**Sustainability Assessment, Energy Economics and Future Power Systems:** Basic concepts of energy economics; importance of cost in selecting power-generation technologies; comparison of electricity-generation costs of conventional and renewable sources; introduction to Levelized Cost of Energy (LCOE); basic concept of life-cycle cost of energy systems; introduction to environmental assessment of power-generation technologies; carbon footprint and greenhouse-gas emissions; basic concept of carbon intensity; comparison of environmental impacts of conventional and renewable energy systems; introduction to green hydrogen and its applications; role of electric vehicles in future energy systems; basic concepts of Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H); introduction to prosumers and peer-to-peer energy trading; and overview of emerging trends in sustainable and intelligent power systems.	12
	TOTAL	**42**

Text Books:

1. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, CRC Press / Fairmont Press.
2. John Twidell and Tony Weir, Renewable Energy Resources, 4th Edition, Routledge, 2021.
3. Janaka B. Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu and Akihiko Yokoyama, Smart Grid: Technology and Applications, Wiley.
4. A. M. Sayigh, Renewable Energy Engineering, Academic Press.

Reference Books:

1. Allen J. Wood, Bruce F. Wollenberg and Gerald B. Sheblé, Power Generation, Operation, and Control, 3rd Edition, Wiley.
2. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Nick Jenkins, Lars T. Berger, Krzysztof Iniewski and James Momoh, Wiley India.
3. V. V. N. Kishore, Renewable Energy Engineering and Technology: Principles and Practice, TERI Press.
4. Frank Kreith and D. Yogi Goswami, Energy Management and Conservation Handbook, CRC Press.
5. Albert Thumann and William J. Younger, Handbook of Energy Audits, Fairmont Press.

E-Resources:

1. NPTEL course on Sustainable Power Generation Systems – Prof. Pankaj Kalita, Department of Energy Science and Engineering, IIT Guwahati - https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ge47
2. NPTEL course on Sustainable Energy Technology – Prof. Sayak Banerjee, IIT Hyderabad

https://nptel.ac.in/courses/112106318

3. NPTEL course on Energy Management Systems and SCADA – Dr. K. Shanti Swarup, IIT Madras – https://nptel.ac.in/courses/108106022
4. Smart Grid: Basics to Advanced Technologies – Prof. N. P. Padhy and Prof. Premalata Jena, IIT Roorkee - https://nptel.ac.in/courses/108107113

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DEPARTMENT OF ELECTRICAL ENGINEERING

Program: B. Tech. with Honours (Electrical Engineering)							**Semester: IV**		
Course: Artificial Intelligence Technology in Power System							**Code:** EEHC422		
Teaching Scheme (Hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
3			3		100				100

Prerequisites:

Basic knowledge of Electrical Engineering, electrical circuits, electrical measurements, electrical power and energy, and basic computer programming concepts.

Course Objectives:

To introduce the fundamental concepts of Artificial Intelligence and Machine Learning and develop an understanding of their basic applications in electrical power systems, including forecasting, monitoring, fault detection, energy management and smart power-system operation.

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

CO1	Explain the basic concepts of Artificial Intelligence, Machine Learning and their applications in electrical power systems.
CO2	Apply basic AI concepts to explain applications such as load forecasting, renewable-energy prediction and energy management in power systems.
CO3	Apply basic AI concepts to electrical fault detection and condition monitoring of power-system equipment.
CO4	Explain emerging applications of AI in smart grids, renewable energy, energy storage, electric vehicles and sustainable power systems.

Course Contents:

Unit	**Description**	**Duration (Hrs.)**
1.	**Introduction to Artificial Intelligence in Electrical Power Systems:** Introduction to Artificial Intelligence (AI) and its importance in engineering; basic concepts of intelligent systems; evolution and applications of AI; difference between conventional programming, Artificial Intelligence and Machine Learning; basic concepts of data, information, features and patterns; types of electrical power-system data such as voltage, current, power, energy and load data; introduction to Machine Learning and Deep Learning and their relationship with AI; basic steps of an AI-based problem-solving process; concepts of training, testing and prediction; advantages and limitations of AI; and overview of AI applications in electrical power generation, transmission, distribution, renewable energy, energy management and power-system monitoring.	10
2.	**AI Applications in Power-System Operation and Management:** Introduction to the use of AI in power-system operation and energy management; basic concept of electrical load forecasting; use of AI and Machine Learning for load prediction; introduction to renewable-energy generation forecasting; basic AI-based monitoring of voltage, frequency, power and energy; applications of AI in energy management; introduction to AI-based generation scheduling and economical operation; AI applications in demand-side management; prediction of electrical energy consumption; applications of AI in smart grids and microgrids; and simple case studies of AI applications in power-system operation and energy management.	10

3.	**AI for Power-System Protection, Fault Detection and Condition Monitoring:** Introduction to electrical faults and abnormal operating conditions in power systems; need for fault detection and diagnosis; basic concept of conventional and AI-based fault identification; introduction to electrical signal data used for fault detection; basic concept of extracting useful information from voltage and current signals; AI-based classification of simple electrical faults; applications of Machine Learning in transmission and distribution-system fault detection; introduction to condition monitoring of transformers and electrical machines; monitoring of parameters such as voltage, current, temperature and vibration; basic concept of equipment health monitoring and predictive maintenance; advantages and limitations of AI-based fault detection and condition monitoring; and simple case studies of AI applications in electrical equipment monitoring.	12
4.	**Emerging AI Applications in Smart and Sustainable Power Systems:** Introduction to AI-enabled smart power systems; applications of AI in smart grids; AI-based renewable-energy management; basic application of Machine Learning for solar and wind power prediction; AI-assisted energy-storage management; applications of AI in electric-vehicle charging and charging-load prediction; introduction to AI-based demand-response management; applications of AI in micro grids and Distributed Energy Resources (DERs); introduction to intelligent energy management systems; basic concept of digital twins in power systems; introduction to responsible and explainable AI; basic issues related to data quality, cyber security and privacy; limitations and challenges of AI applications in power systems; and overview of future applications of AI in intelligent, smart and sustainable power systems.	12
	TOTAL	**42**

Text Books:

1. Ethem Alpaydin, Introduction to Machine Learning, 4th Edition, MIT Press.
2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson.
3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, PHI Learning.

Reference Books:

1. Kevin Warwick, Arthur Ekwue and Rag Aggarwal (Eds.), Artificial Intelligence Techniques in Power Systems, IET.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer.
4. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley.
5. Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning, Springer.

E-Resources:

1. NPTEL course on Introduction to Machine Learning – Prof. Sudeshna Sarkar, IIT Kharagpur - https://nptel.ac.in/courses/106105152
2. NPTEL course on Intelligent Systems and Control – Prof. Laxmidhar Behera, IIT Kanpur - https://nptel.ac.in/courses/108104049
3. Machine Learning – Prof. Balaraman Ravindran, IIT Madras https://nptel.ac.in/courses/106106139
4. NPTEL course on Machine Learning for Engineering and science applications, Prof. Balaji

Srinivasan Prof. Ganapathy Krishnamurthi, IIT Madras - https://nptel.ac.in/courses/106106198

5. NPTEL course on Fuzzy Sets, Logic and Systems & Applications, Prof. Nishchal Kumar Verma, IIT Kanpur - https://nptel.ac.in/courses/108104157

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