K.L.N. COLLEGE OF ENGINEERING

Pottapalayam – 630 612, Sivagangai District

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Estd: 1994

THIRD YEAR

CURRICULUM AND SYLLABUS

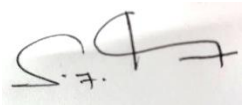
REGULATIONS 2024

For Under Graduate Program

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

CHOICE BASED CREDIT SYSTEM

(For the students admitted from the academic year 2024-2025 onwards)



Dr.S.M.KANNAN,
Professor & Head,
Department of Electrical & Electronics Engineering,
K.L.N. College of Engineering,
Pottapalayam, Sivaganga – 630612

K.L.N. COLLEGE OF ENGINEERING, POTTAPALAYAM
(An Autonomous Institution, Affiliated to Anna University, Chennai)

VISION OF THE INSTITUTION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the society

MISSION OF THE INSTITUTION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry**.**

VISION OF THE DEPARTMENT

To become a high standard of excellence in Education, Training and Research in the field of Electrical & Electronics Engineering and allied applications

MISSION OF THE DEPARTMENT

1. To create graduates possess excellent knowledge in Electrical and Electronics Engineering fundamentals.
2. To provide employable graduates for industry and to do high quality research.
3. To Emphasis on Ethics, professional conduct for societal development

K.L.N. COLLEGE OF ENGINEERING, POTTAPALAYAM

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PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1 To excel in industrial or graduate work in Electrical and Electronics Engineering and allied fields

PEO 2 To practice their Professions conforming to Ethical Values and Environmentally friendly policies

PEO 3 To work in international and multi-disciplinary Environments

PEO 4 To successfully adapt to evolving Technologies and stay current with their Professions

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1 Apply the fundamentals of Mathematics, Science and Engineering knowledge to identify, formulate, design and investigate complex engineering problems of Electric Circuits, Analog and Digital Electronic Circuits, Electrical Machines and Power Systems.

PSO 2 Apply appropriate techniques and modern Engineering hardware and software tools in Power Systems to engage in life- long learning and to successfully adapt in multi-disciplinary environments

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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 to 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)

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)

P08: **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 independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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REGULATIONS 2024

For Under Graduate Program

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

CHOICE BASED CREDIT SYSTEM

CATEGORY OF COURSES

i. **Humanities and Social Sciences (HS) Courses** include Technical English, Environmental Science and Engineering, Engineering Ethics and human values, Communication Skills and Management courses.

ii. **Basic Sciences (BS) Courses** include Mathematics, Physics, and Chemistry.

iii. **Engineering Sciences (ES) Courses** include Engineering Practices, Engineering Graphics, Basics of Electrical / Electronics / Mechanical / Computer Engineering / Instrumentation etc.

iv. **Professional Core (PC) Courses** include the core courses relevant to the chosen programme of study.

v. **Professional Elective (PE) Courses** include the elective courses relevant to the chosen programme of study.

vi. **Open Elective (OE) Courses** include courses from other departments which a student can choose from the list specified in the curriculum of the students B.E. / B.Tech. Programmes.

vii. **Employability Enhancement Courses (EEC)** include Project Work and/or Internship, Seminar, Professional Practices, Case Study and Industrial/Practical Training.

viii. **Mandatory Courses (MC)** include Personality and Character development and the courses recommended by the regulatory bodies such as AICTE, UGC, etc

SEMESTER V

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24EE501	Power System Analysis	PC	4	3	1	0	4
2.	24EE502	Power Electronics	PC	3	3	0	0	3
3.	24EE503	Control Systems	PC	4	3	1	0	4
4.	24EE504	Microprocessors, Microcontrollers and Applications	PC	3	3	0	0	3
5.		Professional Elective-I	PE	3	3	0	0	3
6.		Professional Elective-II	PE	3	3	0	0	3
PRACTICAL								
7.	24EE5L1	Control and Instrumentation Laboratory	PC	3	0	0	3	1.5
8.	24EE5L2	Microprocessor and Microcontrollers Laboratory	PC	3	0	0	3	1.5
9.	24HS5L1	Programming Skills – I (Common to B.E. ECE,EEE,CSE, CSE(CS),CSE(IoT) and B.Tech IT & AIDS programmes)	EEC	2	0	0	2	1*
TOTAL				**28**	**18**	**2**	**8**	**23**
For Honors Degree								
1.		Capstone Design Project - Level I		12	0	0	12	6
OR								
1.		Honors Elective – I		3	3	0	0	3
2.		Honors Elective – II		3	3	0	0	3
For Minor Degree								
1.		Minor Elective – I		3	3	0	0	3
2.		Minor Elective – II		3	3	0	0	3

*** The grades earned by the students will be recorded in the mark sheet, however the same shall not be considered for the computation of CGPA**

 # mandatory Summer internship (2 weeks – 1 credit)

SEMESTER VI

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24EE601	Protection and Switchgear	PC	3	3	0	0	3
2.	24EE602	VLSI Technology	PC	3	3	0	0	3
3.	24EE603	Data Structures using C	ES	3	3	0	0	3
4.	24EE604	Standards in Electrical Engineering	PC	1	1	0	0	1
5.		Open Elective	OE	3	3	0	0	3
6.		Professional Elective-III	PE	3	3	0	0	3
7.		Professional Elective-IV	PE	3	3	0	0	3
8.	24MC601	Disaster Management	MC	2	2	0	0	-
PRACTICAL								
9.	24EE6L1	Power Electronics and Drives Laboratory	PC	3	0	0	3	1.5
10.	24EE6L2	Data Structures using C Laboratory	ES	3	0	0	3	1.5
11.	24EE6L3	Mini project - I	EEC	4	0	0	4	2
12.	24HS6L1	Programming Skills – II (Common to B.E. ECE,EEE,CSE, CSE(CS),CSE(IoT) and B.Tech IT & AIDS programmes)	EEC	2	0	0	2	1*
			TOTAL	**33**	**21**	**0**	**12**	**24**
For Honors Degree								
1.		Capstone Design Project - Level II		12	0	0	12	6
OR								
1.		Honors Elective – III		3	3	0	0	3
2.		Honors Elective – IV		3	3	0	0	3
For Minor Degree								
1.		Minor Elective – III		3	3	0	0	3
2.		Minor Elective – IV		3	3	0	0	3

*** The grades earned by the students will be recorded in the mark sheet, however the same shall not be considered for the computation of CGPA**

PROFESSIONAL ELECTIVE COURSES: VERTICALS

Honors					Minor
Vertical I	**Vertical II**	**Vertical III**	**Vertical IV**	**Vertical V**	
Modern Power System Engineering	**Power Electronics Converters and Drives**	**Electric Vehicle Technology**	**Embedded Systems and VLSI Technology**	**Artificial Intelligence and Data Science for Power system Engineering**	**Electric Vehicles**
Power Quality	Modern Power Converters	Power Electronic Converters for Electric Vehicles	Low Power IC Design	Big Data Analytics In Power Systems	Electrical Machines
Smart Grid	Special Electrical Machines	Electric Vehicles and Power Management	Digital Signal Processing	Generative AI for Power Grid	Power Converters for Electric Vehicles
Flexible AC Transmission System	Solid State Drives	Electric Vehicle Design, Mechanics and Control	Embedded System Design	Python Programming for Data Science	Power Management for Electric Vehicles
Energy Auditing and Management	Control of Electrical Drives	Battery Management System.	Embedded Processors	Data Analytics for Power System Security	Design, Mechanics and Control of Electric Vehicles
High Voltage Engineering	SMPS and UPS	Testing of Electric Vehicles	Embedded C-Programming	Cloud Computing for Power System Applications	Electric Vehicle Charging System
Electric Energy Generation, Utilization and Conservation	Power Electronics for Renewable Energy Systems	Grid Integration of Electric Vehicles	Smart System Automation	Machine Learning Technology and Power System Applications	Electric Vehicles Grid Integration
	Electrical Machine Design		Embedded System for Automotive Applications	Artificial Intelligence for Robotics and Automation	

OPEN ELECTIVE (VI SEMESTER) – R2024 – offered to other Departments

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24OE201	Electrical Energy Auditing and Management	OE	3	3	0	0	3
2.	24OE202	Renewable Energy Sources and Technologies	OE	3	3	0	0	3
3.	24OE203	Electric Vehicles	OE	3	3	0	0	3
4.	24OE204	Biomedical Instrumentation	OE	3	3	0	0	3

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B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL – I: MODERN POWER SYSTEM ENGINEERING

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEV11	Power Quality	PE	3	3	0	0	3
2.	24EEV21	Smart Grid	PE	3	3	0	0	3
3.	24EEV31	Flexible AC Transmission System	PE	3	3	0	0	3
4.	24EEV41	Energy Auditing and Management	PE	3	3	0	0	3
5.	24EEV51	High Voltage Engineering	PE	3	3	0	0	3
6.	24EEV61	Electric Energy Generation, Utilization and Conservation	PE	3	3	0	0	3

VERTICAL – II: POWER ELECTRONICS CONVERTERS AND DRIVES

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEV12	Modern Power Converters	PE	3	3	0	0	3
2.	24EEV22	Special Electrical Machines	PE	3	3	0	0	3
3.	24EEV32	Solid State Drives	PE	3	3	0	0	3
4.	24EEV42	Control of Electrical Drives	PE	3	3	0	0	3
5.	24EEV52	SMPS and UPS	PE	3	3	0	0	3
6.	24EEV62	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
7.	24EEV72	Electrical Machine Design	PE	3	3	0	0	3

VERTICAL – III: ELECTRIC VEHICLE TECHNOLOGY

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEV13	Power Electronic Converters for Electric Vehicles	PE	3	3	0	0	3
2.	24EEV23	Electric Vehicles and Power Management	PE	3	3	0	0	3
3.	24EEV33	Electric Vehicle Design, Mechanics and Control	PE	3	3	0	0	3
4.	24EEV43	Battery Management System	PE	3	3	0	0	3
5.	24EEV53	Testing of Electric Vehicles	PE	3	3	0	0	3
6.	24EEV63	Grid Integration of Electric Vehicles	PE	3	3	0	0	3

VERTICAL – IV: EMBEDDED SYSTEMS AND VLSI TECHNOLOGY

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEV14	Low Power IC Design	PE	3	3	0	0	3
2.	24EEV24	Digital Signal Processing	PE	3	3	0	0	3
3.	24EEV34	Embedded System Design	PE	3	3	0	0	3
4.	24EEV44	Embedded Processors	PE	3	3	0	0	3
5.	24EEV54	Embedded C- Programming	PE	3	3	0	0	3
6.	24EEV64	Smart System Automation	PE	3	3	0	0	3
7.	24EEV74	Embedded System for Automotive Applications	PE	3	3	0	0	3

VERTICAL – V: ARTIFICIAL INTELLIGENCE AND DATA SCIENCE FOR POWER SYSTEM ENGINEERING

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEV15	Big Data Analytics In Power Systems	PE	3	3	0	0	3
2.	24EEV25	Generative AI for Power Grid	PE					
3.	24EEV35	Python programming for Data Science	PE	3	3	0	0	3
4.	24EEV45	Data Analytics for Power System Security	PE	3	3	0	0	3
5.	24EEV55	Cloud Computing for Power System Applications	PE	3	3	0	0	3
6.	24EEV65	Machine Learning Technology and Power System Applications	PE	3	3	0	0	3
7.	24EEV75	Artificial Intelligence for Robotics and Automation	PE	3	3	0	0	3

VERTICAL – MINOR – ELECTRIC VEHICLES

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	24EEM01	Electrical Machines	MD	3	3	0	0	3
2.	24EEM02	Power Converters for Electric Vehicles	MD	3	3	0	0	3
3.	24EEM03	Power Management for Electric Vehicles	MD	3	3	0	0	3
4.	24EEM04	Design, Mechanics and Control of Electric Vehicles	MD	3	3	0	0	3
5.	24EEM05	Electric Vehicle Charging System	MD	3	3	0	0	3
6.	24EEM06	Electric Vehicles Grid Integration	MD	3	3	0	0	3

24EE501	POWER SYSTEM ANALYSIS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To model the power system under steady state operating condition.
- To apply numerical methods to solve the power flow problem.
- To model and analyze the system under symmetrical faulted conditions.
- To model and analyze the system under unsymmetrical faulted conditions.
- To model and analyze the transient behaviour of power system when it is subjected to a fault.

UNIT - I INTRODUCTION 9+3

Need for power system planning and operational studies — basic components of a power system - Single line diagram — per phase and per unit analysis — Generator - transformer — transmission line and load representation for different power system studies - Primitive network - construction of Y-bus using inspection and singular transformation methods.

UNIT - II POWER FLOW ANALYSIS 9+3

Importance of power flow analysis in planning and operation of power systems - statement of power flow problem - classification of buses - development of power flow model in complex variables form - iterative solution using Gauss-Seidel method - Q-limit check for voltage- controlled buses — power flow model in polar form - iterative solution using Newton-Raphson method.

UNIT - III FAULT ANALYSIS – BALANCED FAULTS 9+3

Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem - Z-bus building algorithm - fault analysis using Z-bus — computations of short circuit capacity, post fault voltages and currents

UNIT - IV FAULT ANALYSIS – UNBALANCED FAULTS 9+3

Introduction to symmetrical components — sequence impedances — sequence circuits of synchronous machine, transformer and transmission lines - sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.

UNIT - V STABILITY ANALYSIS 9+3

Importance of stability analysis in power system planning and operation - classification of power system stability - angle and voltage stability — Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time– solution of swing equation by modified Euler method and Runge-Kutta fourth order method.

TOTAL: 45 + 15 PERIODS

TEXT BOOKS:

1. D.P. Kothari, I.J.Nagrath and R.K.Saket, 'Modern Power System Analysis', McGraw-Hill, Fifth Edition, 2022.
2. John J. Grainger and W.D. Stevenson Jr., 'Power System Analysis', Tata McGraw-Hill, Sixth reprint, 2017.

REFERENCES:

1. Kundur P., 'Power System Stability and Control', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.
2. Pai M A, 'Computer Techniques in Power System Analysis', Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, Second Edition, 2007.
3. Hadi Saadat, 'Power System Analysis', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: POWER SYSTEM ANALYSIS		**Course Code : 24EE501**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply the mathematical and engineering knowledge to form bus admittance matrix and impedance matrix	I	K3
CO2	Apply Gauss-Seidel and Newton Raphson methods to solve the load flow problem	II	K3
CO3	Analyze the power system under steady state symmetrical fault	III	K4
CO4	Analyze the power system under unsymmetrical faults	IV	K4
CO5	Analyze the stability of the power system using equal area criteria and swing equation	V	K4

24EE502	POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various applications of Power electronic devices for conversion, control and conditioning of the electrical power and to get an overview of different types of power semiconductor devices and their dynamic characteristics.
- To understand the operation, characteristics and performance parameters of controlled rectifiers.
- To study the operation, switching techniques and basic topologies of DC-DC switching regulators.
- To learn the different modulation techniques of pulse width modulated inverters
- To study the operation of AC voltage controller and various configurations of AC voltage controller.
-

UNIT - I POWER SEMI-CONDUCTOR DEVICES 9

Study of switching devices, SCR, TRIAC, GTO, BJT, MOSFET, IGBT and IGCT- Static characteristics: SCR, MOSFET and IGBT - Triggering and commutation circuit for SCR, Introduction to Driver and snubber circuits.

UNIT - II PHASE-CONTROLLED CONVERTERS 9

2- pulse, 3-pulse and 6-pulseconverters – performance parameters – Effect of source inductance – Firing Schemes for converter – Dual converters, Applications - light dimmer, Excitation system, Solar PV systems.

UNIT - III DC TO DC CONVERTERS 9

Step-down and step-up chopper - control strategies - Buck, Boost, and Buck-Boost - Performance analysis - PWM techniques for choppers - Switched mode regulators — Applications - Battery operated vehicles.

UNIT - IV INVERTERS 9

Single phase and three phase voltage source inverters (both120˚ mode and 180˚ mode) – Voltage & harmonic control - PWM techniques: Multiple PWM, Sinusoidal PWM, modified sinusoidal PWM — Introduction to space vector modulation — Current source inverter, Applications - Induction heating, UPS.

UNIT - V AC TO AC CONVERTERS 9

Single phase and Three phase AC voltage controllers – Control strategy - Power Factor Control – Multistage sequence control - single phase and three phase cyclo converters – Introduction to Matrix converters, Applications – welding.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Muhammad H.Rashid, 'Power Electronics Circuits, Devices & Applications', 4th Edition, Pearson India, 2017
2. P.S.Bimbra, 'Power Electronics', Khanna Publishers, Fifth Edition, 2014.

REFERENCES:

1. Ned Mohan, Tore.M.Undeland, William.P.Robbins, 'Power Electronics: Converters, Applications and Design', 3rd Edition Wiley India, New Delhi, 2007.
2. M.D.Singh & K.B Khanchandani, 'Power Electronics', 2nd Edition, Tata McGraw Hill Publishing Co.Ltd., New Delhi, 2008.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : POWER ELECTRONICS		**Course Code : 24EE502**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the significance of switching devices and its application to power converters and its characteristics	I	K2
CO2	Apply the knowledge of engineering fundamentals to derive the performance parameters of 2 pulse, 3 pulse and 6 pulse converter	II	K3
CO3	Apply the knowledge of engineering fundamentals to derive the performance analysis of Buck, Boost, Buck-Boost converters	III	K3
CO4	Analyze the operation of single phase and three phase Voltage Source Inverters and Current Source Inverters	IV	K4
CO5	Apply the knowledge of engineering fundamentals for the operation of single, three phase AC Voltage controllers and Cyclo converters	V	K3

24EE503	CONTROL SYSTEMS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To understand the use of transfer function models to analyze physical systems.
- To provide adequate knowledge in the time response of systems and steady state error analysis.
- To accord basic knowledge in obtaining the open loop and closed–loop frequency responses of systems.
- To introduce stability analysis and design of compensators.
- To introduce state variable representation of physical systems.

UNIT - I SYSTEMS AND REPRESENTATION 9+3

Concepts of Control Systems – Open and Closed loop systems - Transfer functions – Mathematical modeling - Electrical, Mechanical and Electromechanical systems - Electrical analogous of Mechanical systems — Block diagram - Signal flow graph

UNIT - II TIME RESPONSE ANALYSIS 9+3

Standard test signals – Time responses - Time domain specifications – Poles and zeros and their effects on solutions - Steady state error and error constants - Introduction to PI, PD and PID Controllers.

UNIT - III FREQUENCY RESPONSE ANALYSIS 9+3

Performance specification in frequency domain — Frequency response of standard second order system - Bode plot – Polar plot – Introduction to closed loop Frequency Response – Introduction to Lag, Lead and Lag-Lead compensator.

UNIT - IV CONCEPTS OF STABILITY ANALYSIS 9+3

The concept of stability – Routh Hurwitz stability criterion – Root Locus Technique: The root locus concept – construction of root loci - Effect of adding poles and zeros – Nyquist stability criterion.

UNIT - V STATE VARIABLE ANALYSIS 9+3

Concepts of State, State variables and State models - State space equations — State space representation of dynamic systems - Transfer function from State Variable Representation - State transition matrix – Concepts of controllability and observability.

TOTAL: 45+15 PERIODS

TEXT BOOKS:

1. Nagarath, I.J. and Gopal, M., ‘Control Systems Engineering’, New Age International Publishers, 2017.
2. Katsuhiko Ogata, ‘Modern Control Engineering’, Pearson, 2015.

REFERENCES:

1. Benjamin C. Kuo, 'Automatic Control Systems', Wiley, 2014.
2. Richard C.Dorf and Bishop, R.H., 'Modern Control Systems', Pearson Education, 2009
3. Ashfaq Husain, Haroon Ashfaq, 'Control Systems', Dhanpat Rai & Co., 2015

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: CONTROL SYSTEMS		**Course Code: 24EE503**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply the knowledge of mathematics, Engineering fundamentals to develop mathematical models for physical system and simplify it using reduction techniques.	I	K3
CO2	Apply the knowledge of mathematics, Engineering fundamentals to compute the time domain responses of first and second-order systems to test inputs.	II	K3
CO3	Analyze the stability of the system using different frequency domain methods.	III	K4
CO4	Analyze the behavior of closed loop systems using tools such as Root locus technique, Routh Hurwitz and Nyquist Criteria	IV	K4
CO5	Apply the knowledge of mathematics, Engineering fundamentals to develop state space models.	V	K3

24EE504 MICROPROCESSORS, MICROCONTROLLERS AND APPLICATIONS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the Architecture of 8086 microprocessor.
- To develop skills in simple program writing in assembly languages
- To introduce commonly used peripheral/ interfacing ICs.
- To study and understand typical applications of micro-processors.
- To study and understand the typical applications of micro-controllers

UNIT - I INTRODUCTION TO 8086 MICROPROCESSOR **9**

Introduction to 8086 – Microprocessor architecture – Addressing modes - Instruction set and assembler directives – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines – Byte and String Manipulation.

UNIT - II 8086 SYSTEM BUS STRUCTURE **9**

Basic configurations – System bus timing –System design using 8086 – I/O programming – Introduction to Multiprogramming – System Bus Structure – Multiprocessor configurations – Coprocessor, Closely coupled and loosely Coupled configurations.

UNIT - III INTERFACING BASICS AND ICS **9**

Study of Architecture and programming of ICs: 8255 PPI, 8259 PIC, 8251 USART, 8279 Key board display controller and 8254 Timer/ Counter – Interfacing with 8086 - A/D and D/A converter interfacing.

UNIT - IV INTRODUCTION TO 8051 MICROCONTROLLER **9**

Functional block diagram - Instruction format and addressing modes – Interrupt structure – Timer – I/O ports – Serial communication, Simple programming- key board and display interface Temperature control system - stepper motor control - Usage of integrated development environment (IDE) for assembly language programming

UNIT – V ARDUINO UNO BOARD **9**

Introduction-Interfacing of Digital Input (LED) and Output devices (Switch)-Interfacing of Current sensor and LCD, real time digital clock using Arduino, Room Temperature Monitor & Visitor Counter, design of traffic light controller

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Application', Pen ram International (P)ltd., Mumbai, 6th Education, 2013.
2. Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely, 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2007.

REFERENCES:

1. Ayala, Kenneth J, 'The 8051 microcontrollers: architecture, programming, and applications', Cengage Learning India; 3rd edition, 2007
2. Douglas V.Hall, 'Microprocessor and Interfacing', McGraw Hill Edu, 2016.
3. Krishna Kant, 'Microprocessor and Microcontrollers', Eastern Company Edition, Prentice Hall of India, New Delhi, 2007
4. Muhammad Ali Mazidi & Janice Gilli Mazidi, 'The PIC Micro Controller and Embedded systems,2010.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: Microprocessors, Microcontrollers and Applications		**Course Code: 24EE504**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Develop and execute programs in 8086 microprocessors.	I	K3
CO2	Explain and build the System Bus structure of 8086 microprocessor.	II	K3
CO3	Illustrate the interfacing of peripheral with microprocessor and microcontroller	III	K3
CO4	Construct the architecture and Interrupt structure of 8051 and Design microcontroller based Temperature control and stepper motor control system.	IV	K3
CO5	Illustrate the architecture of Arduino UNO board.	V	K3

24EE5L1	CONTROL AND INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To provide knowledge on analysis and design of control system along with basics of instrumentation.

LIST OF EXPERIMENTS:

CONTROLSYSTEMS:

1. P, PI and PID controllers.
2. Stability Analysis.
3. Modeling of Systems – Machines, Sensors and Transducers.
4. Design of Lag, Lead and Lag-Lead Compensators.
5. Position Control Systems.
6. Synchro - Transmitter-Receiver and Characteristics.
7. Simulation of Control Systems by Mathematical development tools.

INSTRUMENTATION:

8. Bridge Networks – AC and DC Bridges
9. Dynamics of Sensors/Transducers

(a) Temperature
(b) Pressure
(c) Displacement
(d) Optical
(e) Strain
(f) Flow

10. Signal Conditioning

(a) Instrumentation Amplifier
(b) Analog –Digital and Digital–Analog converters (ADC and DAC's)

TOTAL: 45 PERIODS

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : CONTROL AND INSTRUMENTATION LABORATORY		Course Code : 24EE5L1	
CO	**Course Outcomes**	**Exp**	**K –CO**
CO1	Analyze the characteristics of P, PI, PID controllers and the stability of the control system using MATLAB.	1,2	K4
CO2	Compute the transfer function of a Field controlled DC motor experimentally and analyze the response of Lag, Lead and Lag-Lead Compensators.	3,4	K3
CO3	Analyze the transient response of Position Control system experimentally and analyze the Characteristics of Synchro - Transmitter- Receiver.	5,6	K4
CO4	Use MATLAB for the Simulation of Control Systems.	7	K3
CO5	Analyze the basic concepts of bridge networks, Dynamics of Sensors/Transducers, and signal conditioning circuits.	8,9,10	K4

24EE5L2	MICROPROCESSORS AND MICROCONTROLLERS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To perform simple arithmetic operations using assembly language program and study the addressing modes & instruction set of 8086 & 8051.
- To write an assembly language program to convert Analog input to Digital output and Digital input to Analog output.
- To perform interfacing experiments with µP8086.

LIST OF EXPERIMENTS:

8086 Programs using kits:

1. Basic arithmetic and Logical operations.
2. Move a data block without overlap.
3. Code conversion, decimal arithmetic and Matrix operations.
4. Floating point operations, string manipulations, sorting and searching.
5. Counters and Time Delay.

Peripherals and Interfacing Experiments:

6. Traffic light controller.
7. Stepper motor control.
8. Key board and Display.
9. Serial interface and Parallel interface.
10. A/D and D/A interface and Waveform Generation.

8051 Experiments using kits:

11. Basic arithmetic and Logical operations.
12. Square, Cube program and 2‘s complement of a number.

TOTAL: 45 PERIODS

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: Microprocessors and Microcontrollers Laboratory		Course Code: 24EE5L2	
CO	**Course Outcomes**	**Exp**	**K –CO**
CO1	Develop an assembly language program for arithmetic, Logical operations using 8086 processor and to move a data block without overlap.	1,2	K3
CO2	Develop program for code conversion, decimal arithmetic, Matrix operations and Floating point operations.	3,4	K3
CO3	Develop program for Counters, Time Delay and Traffic light controller.	5,6	K3
CO4	Develop programs for serial communication and Stepper motor control	7,8	K3
CO5	Demonstrate the program of Serial interface, Parallel interface, A/D, D/A interface and Waveform Generation, Develop an assembly language program for arithmetic, Logical operations.	9,10, 11,12	K3

24HS5L1	PROGRAMMING SKILLS I	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To u**nderstand** the fundamental data structures (stack, queue, heap, binary tree) and their applications in problem solving.
- To a**pply** searching and traversal algorithms to solve problems efficiently under time and memory constraints.
- To a**nalyze** real-world problem statements and map them to suitable data structures and algorithms.
- To e**valuate** algorithmic solutions for correctness, performance, and optimality in competitive coding scenarios.
- To c**reate** modular, efficient programs by combining multiple algorithmic concepts

1. **Sample problems to be solved**

   Story Book Stack

   Arun reads lot of story books and he keeps all the story books piled as a single stack. He wants to write a program to keep the order of the books in the pile. The program must implement the following functionalities.

   - Add a book to the top of the pile when 1 is followed by the name of the book.
   - Remove a book from the top of the pile when -1 is given as the input(provided the pile has atleast one book).
   - Print the name of the book on the top of the pile when 2 is given as the input (provided the pile has atleast one book).
   - The program must exit when 0 is given as the input.

   Boundary Condition(s):

   The maximum number of story books in the pile will be 100.

   The name of the book will not exceed 100 characters.

2. **Shorter left wind mill**

   There are N wind mills in a straight line from left to right. The height of all N wind mills is passed as the input. For each wind-mill M, the program must print the number of wind-mills which are shorter than the current wind-mill present to the left of M.

   Note: If private test cases fail implement the logic using an algorithm which is efficient - complexity is less, han O(n2)

   Boundary Condition(s):

   1 <= N <= 10^6,1 <= Height of wind mill <= 10^5

3. **First K Largest Integer**

   The program must accept N integers and an integer K as the input. The program must print the first K largest integers among theN integers as the output.

   Hint: The value of N will be large, so sorting N integers and printing the first K integers gives the timeout for this program.

   Boundary Condition(s):1 <= N <= 10^5, 1 <= Each integer value <= 10^8, 1 <= K <= N

4. There are N baskets with different number of balls. The number of balls in each basket is passed as input to the program. The program must make all the baskets with at least B balls based on the following condition.

   -Two baskets with the least number of balls 81 and 82 can be combined to form a new basket with 81 + (2 x B2) balls where 81 < B2.

   Note: Additional balls will be supplied as needed from the store

   The value of B is also passed as the input to the program. The program must print the number of times T the baskets can be combined to make all the baskets with at least B

   Ball **Boundary Condition(s):**1 <= N <= 10^6

   <= Number of balls in each basket <= 10^6,1 <= B <= 10^9

5. There are N queues maintained in a railway station to process customer's query. Each customer will take different time to process his/her query. The customer id and the timetaken to process the customer's query of each customer in each queue are given as the input. The program must print the customer id of Kth serviced customer as the output Ifmore than one customer has serviced at the same time as the Kth customer then print the customer id having the minimum value among those customer ids.

   Boundary Condition(s):

   1 <= N <= 100

   1 <= Size of each queue <= 100

   1 .< = K < = Total number of customers in all the queues

   1 <= Customer id, Time taken to process the customer's query <= 1045

6. In an organization chart, the team members are represented using a binary tree. A team member can have a maximum of two junior team members under him/her. It is possible that a team member does not have any juniors under him/her.

   Annual performance allowance is to be paid and the allowance amount that can be paid to the team member on the top of the hierarchy is passed as the input. A junior will get half the amount of the allowance of his/her senior if two juniors are under the senior. Else the junior will get the same amount as allowance as the senior.

   Fill in the missing lines of code to complete the implementation for the function find Min

Allowance so that it returns the least possible allowance paid to a team member.

Note:

- Curr Node which is passed as the argument is the root node of the binary tree.
- Net worth is the allowance amount receivable by the team member represented by the curr Node
- currMin Allowance is the currently payable minimum allowance amount to an team member at curr Node.

The struct Node is as given below (Here data is not needed for calculation but represents a positive integer)

```
struct Node
{
int data;
struct Node "left, "right;
};
```

You can create and implement additional functions (methods) as per your requirement

Boundary Condition(s):1 <= Value of a Node <= 1000

7. Fill in the missing lines of code to complete the implementation for the function mirror so that it mirrors the given binary tree.

Note: currentNode which is passed as the argument is the root node of the binary tree.

The struct Node is as given below.

```
struct Node
{
int data;
struct Node *left, *right;
};
```

You can create and implement additional functions (methods) as per your requirement.

Boundary Condition(s):

1 <= Value of a Node <= 1000

8. The program must accept a string S as the input. The program must print the first occurring vowel in the string S as the output. Ifthere is no vowel in the string S then the program must print -1 as the output.

Boundary Condition(s):1 <= Length of S <= 1000

9. The program must accept two string values S1 (may contain space) and S2 (one word) as the input. The words in S1 are sortedlexicographically and separated by exactly one space. The

program must insert the the string 52 in S1 such that all the words inthe modified $1 are also in sorted order.

Note: The string values contain only lower case alphabets

Boundary Condition(s):1 <= Length of S1 <= 1000,1 <= Length of S2 <= 100

10. A maze is given as an NxN matrix containing only Os and 1s. In the maze matrix, 0 represents a blocked cell and 1represents an open cell. The program must accept the maze matrix of size NxN as the input. There are a rabbit anda carrot inside the maze whose positions R(x, y) and C(x, y) are also passed as input to the program. The rabbitcan move inside the maze based on the following condition.

- The rabbit can move along any row or column in any direction until it reaches the edge of the maze or a blockedcell.

The program must print the minimum number of straight-line traversals T along a row or a column required forthe rabbit to reach the carrot as the output.

Note: The maze matrix is always having at least a path from the rabbit to the carrot.

Boundary Condition(s):1 <= N <= 100

TOTAL: 30 PERIODS

REFERENCES

1. https://skillrack.com/faces/candidate/codeprogram.xhtml
2. https://www.geeksforgeeks.org/blogs/how-to-approach-a-coding-problem/
3. https://leetcode.com/

24EE601	PROTECTION AND SWITCH GEAR	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on the following

- Causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- Characteristics and functions of relays and protection schemes.
- Apparatus protection, static and numerical relays
- Functioning of circuit breaker

UNIT - I OVERVOLTAGE PROTECTION 9

Causes and Effects of Over Voltages - Switching and lightning over voltages – Lightning Mechanism – Lightning Arresters and surge diverters

UNIT - II ELECTROMAGNETIC RELAYS 9

Zones of protection and essential qualities of protection- Operating principles of relays - the Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays.

UNIT - III APPARATUS PROTECTION 9

Current transformers and Potential transformers applications in protection schemes -Protection of transformer, generator, motor, bus bars and transmission line

UNIT - IV NUMERICAL PROTECTION 9

Block diagram of Numerical relays – Over current protection, transformer differential protection, distance protection of transmission lines – Programming for over current, directional and distance protection.

UNIT - V CIRCUIT BREAKERS 9

Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching - current chopping - interruption of capacitive current - Types of circuit breakers – air blast, air break, oil, SF6, and vacuum circuit breakers, MCBs, MCCBs – comparison of different circuit breakers – Rating and selection of Circuit breakers.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Badri Ram, B.H. Vishwakarma, 'Power System Protection and Switchgear', New Age International (P) Ltd, 2nd Edition, 2017.
2. Y.G.Paithankar and S.R.Bhide, 'Fundamentals of power system protection', 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.

REFERENCES:

1. Sunil S.Rao, 'Switchgear and Protection', Shree Hari Publications, New Delhi, 2021.
2. VK Metha, "Principles of Power Systems" S. Chand, 2005.
3. A. Chakrabarti, M.L. Soni, P.V. Gupta, U.S. Bhatnagar, "A textbook on Power system Engineering" Dhanpat Rai Publishing Company (P) Ltd.2008
4. C.L.Wadhwa, "Electrical Power Systems", New Age International Private Limited, 2022
5. B.Rabindranath and N.Chander, 'Power System Protection and Switchgear', New Age International (P) Ltd., First Edition 2018.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: PROTECTION AND SWITCHGEAR		**Course Code: 24EE601**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the Over voltage Protection of Power Systems	I	K2
CO2	Explain the characteristics and functions of Electromagnetic type protective relays	II	K2
CO3	Classify the various abnormal conditions in power system apparatus and to select a suitable protection scheme	III	K3
CO4	Develop assembly language programming for numerical over current, directional and distance protection	IV	K3
CO5	Analyze the circuit interruption problems and Explain the operation of Air, Oil, SF6 and Vacuum Circuit Breakers	V	K4

24EE602	VLSI TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the basic concepts of CMOS
- To introduce the IC fabrication methods
- To introduce the Reconfigurable Processor technologies
- To introduce the basics of analog VLSI design and its importance.
- To learn about the programming of Programmable device using Hardware description Language.

UNIT I MOS Transistor principle **9**

NMOS and PMOS transistors, Process parameters for MOS and CMOS, Electrical properties of CMOS circuits and device modelling, scaling principles and fundamental limits, CMOS inverter scaling. Propagation delays, Stick diagram, Layout diagrams.

UNIT II Combinational Logic Circuits **9**

Examples of combinational logic design, Elmore's constant, pass transistor logic, Transmission gates, Static and dynamic CMOS design, Power dissipation – Low power design principles.

UNIT III Sequential Logic Circuits **9**

Static and Dynamic latches and registers, Timing issues, Pipelines, Clock strategies, Memory architecture and memory control circuits. Low power memory circuits, Synchronous and Asynchronous design.

UNIT IV Designing Arithmetic Building Blocks **9**

Data path circuits, Architecture for ripple carry adders, Carry look ahead adders, High speed adders, Accumulators. Multiplier, Dividers, Barrel shifters, Speed and area trade-off.

UNIT V Implementation Strategies **9**

Full custom and semi custom design, Standard cell design and cell libraries, FPGA building block architectures, FPGA interconnect routing procedures.

TEXT BOOKS:

1. M.J.S Smith, "Application Specific integrated circuits", Addition Wesley Longman Inc. 1st Edition 2010.
2. Kamran Eshraghian, Douglas A.pucknell and Sholeh Eshraghian, "Essentials of VLSI circuits and system", Prentice Hall India,2005, 1st Edition.
3. N. H. E. Weste, D.F. Harris, "CMOS VLSI design", (3/e), Pearson, 2005.

REFERENCES:

1. Charles H. Roth Jr., "Fundamentals of Logic design", Thomson Learning, 7th Edition 2013.
2. Pucknell & Eshraghian, "Basic VLSI Design", PHI, (3/e), 2003
3. Uyemura, "Introduction to VLSI Circuits and Systems", Wiley, 2002.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: VLSI TECHNOLOGY		Course Code: 24EE602	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Develop MOS design techniques	I	K3
CO2	Illustrate various combinational logic circuits	II	K3
CO3	Classify various sequential logic circuits	III	K3
CO4	Explain and develop arithmetic building blocks.	IV	K3
CO5	Classify the various implementation strategies of FPGA	V	K3

24EE603	DATA STRUCTURES USING C	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of ADTs.
- To learn the concepts of linear data structures.
- To learn the concepts of non-linear data structures and hashing.
- To explore the applications of linear and non-linear data structures
- To get familiarized to sorting and searching algorithms.

UNIT I ARRAYS AND LISTS **9**

Abstract Data Types (ADTs) – List ADT – Array-based implementation – Linked list – Doubly- Linked Lists – Circularly Linked List – Polynomial Manipulation using Linked List.

UNIT II STACKS AND QUEUES **9**

Stack ADT- Implementation of Stack - Applications: Evaluating Postfix Expressions, Infix to Postfix conversion -Queue ADT -Queue Implementation - Applications.

UNIT III TREES **9**

Trees - Binary Trees -Tree Traversals - Expression Trees - Binary Search Tree - AVL Trees, B-Tree, B+ Tree- Heap representation.

UNIT IV GRAPHS **9**

Graph Definition - Representation of Graphs - Types of Graph - Breadth-first traversal Depth- first traversal - Applications of Graphs - Dijkstra's Algorithm - Prim's a lgorithm - Kruskal's Algorithm.

UNIT V SEARCHING, SORTING AND HASHING TECHNIQUES **9**

Linear Search – Binary Search - Insertion sort - Selection sort - Merge Sort -Quick sort, Bubble sort,Radix sort- Hashing -Hash Functions - Separate Chaining - Open Addressing - Double Hashing – Rehashing- b Extendable hashing.

TOTAL:45 PERIODS

TEXT BOOKS:

1. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education, 2002.
2. Kamthane, "Introduction to Data Structures in C", 1st Edition, Pearson Education, 2007.

REFERENCES:

1. E.Balagurusamy, "Data Structures using C", 1st Edition, Mc-Graw Hill, 2013.
2. Langsam, Augenstein and Tanenbaum, "Data Structures using C and C++", 2nd Edition, Pearson Education, 2015.
3. Kruse, "Data Structures and Program Design in C", 2nd Edition, Pearson Education, 2006.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: DATA STRUCTURES USING C		**Course Code: 24EE603**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply abstract data types and implement various algorithmic problems using arrays and linked list.	I	K3
CO2	Apply the different linear data structures like stack and queue to solve various II K3 computing problems	II	K3
CO3	Build different types of trees and apply various operations for tree manipulation	III	K3
CO4	Solve graph based problem using traversal techniques and path finding	IV	K3
CO5	Apply different sorting, searching and hashing techniques for data manipulation and storing	V	K3

24MC601	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	--

OBJECTIVES:

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

UNIT – I INTRODUCTION 6

Disaster: Definition, Factors and Significance, Difference between Hazard and Disaster.

Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT – II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem.

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches.

Man-made Disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Out breaks of Disease and Epidemics, War and Conflicts.

UNIT – III DISASTER PRONE AREAS IN INDIA 6

Disaster Prone are as in India: Study of Seismic Zones, Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post – Disaster Diseases and Epidemics.

UNIT – IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard.

Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other Agencies.

Media Reports: Governmental and Community Preparedness.

UNIT - V RISK ASSESSMENT 6

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co - Operation In Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

TOTAL: 30 PERIODS

REFERENCES:

1. Nishith Rai and A.K. Singh, "Disaster Management in India: Perspectives, Issues and Strategies", New Royal Book Company, 2007.
2. Pardeep Sahni, Alka Dhameja and Uma Medury, "Disaster Mitigation: Experiences and Reflections", Prentice Hall India Learning Private Limited, 2001.
3. S.L.Goel,"Disaster Administration and Management: Text and Case Studies",Deep & Deep Publication Pvt.Ltd., 2007

24EE604 STANDARDS IN ELECTRICAL ENGINEERING

L	T	P	C
1	0	0	1

UNIT-I- OVERVIEW OF STANDARDS 6

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation-Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards

UNIT-II- ELECTRICAL INSTALLATION IN BUILDING 9

IS 18732 : 2023-Layout - Planning and Design- IS/IEC 61936 (Part 1) - Installation of Equipment Safety Services-2023 National Electrical Code -Typical Distribution System- Electrical Installations in Industrial Buildings and Agricultural Premises-Hazardous Areas- IS 1646: 2002-General Requirements - Transformer Substation- IS3043- Earthing practices- IS732- 2019 Code of Practice for Wiring Methods-Special Electrical Equipment and Locations and Testing-Portable Fire Extinguishers-IS 15683 - Classification of Extinguishers- Construction Requirement-Tests.

TOTAL:15 PERIODS

TEXT BOOKS:

1. Is 18732 : 2023 Guide For Implementation Of Electrical Installation Standards In Buildings Is 1646: 2022 Fire Safety Of Buildings (General): Electrical Installations
2. Indian Standard Portable Fire Extinguishers — Performance And Construction —Specification (First Revision) Is 15683 : 2018 2023 National Electrical Code (Nec®)

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : STANDARDS IN ELECTRICAL ENGINEERING		**Course code:** 24EE604
CO	**Course Outcomes**	**K –CO**
CO1	Describe the General Aims and Principles of Standardization with Functions of Standardization Set up In BIS	K2
CO2	Outline Good Practices for the Selection of Electrical Equipment Forming Part of An Electrical Installation	K2
CO3	Summarize the Practice of NEC for Installations	K2
CO4	Explain the General Safety Procedures and Practices In Electrical Work	K2
CO5	Compile Basic Knowledge on Various Types of Fire Protections	K2

24EE6L1 POWER ELECTRONICS AND DRIVES LABORATORY

L	T	P	C
0	0	3	1.5

OBJECTIVES:

- To examine the characteristics of various power electronics devices.
- To outline the performance characteristics of Converter, chopper, AC voltage controller, inverter and Switched mode power converter.
- To gain practical experience on converter, chopper fed dc motor drives.
- To gain practical experience on Inverter fed induction motor drives.
- To simulate the basic topological power converter circuits.

LIST OF EXPERIMENTS:

1. Characteristics of SCR and Gate Pulse Generation using R, RC and UJT.
2. Characteristics of TRIAC and IGCT.
3. Characteristics of MOSFET and IGBT.
4. Single phase AC to DC Semi converter / Simulation of semi converters.
5. Single phase AC to DC fully controlled Converter / Simulation of full converters.
6. Step down and step up MOSFET based choppers / Simulation of DC-DC converters.
7. Single phase AC Voltage controller / Simulation of AC voltage controllers.
8. Switched mode power converter.
9. IGBT based Single phase PWM inverter.
10. IGBT based Speed control of three phase PWM inverter fed Induction motor.
11. Micro controller based speed control of Converter and Chopper fed DC motor.

TOTAL: 45 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : Power Electronics And Drives Laboratory		**Course Code: 24EE6L1**	
CO	**Course Outcomes**	**Exp**	**K –CO**
CO1	Experimentally generate the gate pulse of SCR using R, RC and UJT triggering circuits and differentiate the VI characteristics of power electronics devices.	1,2, 3	K3
CO2	Experimentally analyze the performance of the single phase AC to DC semi converter and fully controlled converter with R and RL load using MATLAB simulation tool.	4,5	K4
CO3	Experimentally analyze the performance of the designed step down and step up MOSFET based choppers using MATLAB simulation tool.	6	K4
CO4	Experimentally analyze the performance of the designed AC –AC converters and Switched mode power converter using MATLAB simulation tool.	7,8	K4
CO5	Analyze the frequency response of single phase PWM inverter and inverter fed induction motor drive.	9,10, 11	K3

24EE6L2 DATA STRUCTURES USING C LABORATORY

L	T	P	C
0	0	3	1.5

OBJECTIVES:

- To understand the concepts of ADTs.
- To learn the concepts of linear data structures.
- To learn the concepts of non-linear data structures and hashing.
- To explore the applications of linear and non-linear data structures
- To get familiarized to sorting and searching algorithms.

LAB COMPONENT

1. Implementation of Singly Linked List
2. Implementation of Polynomial Manipulation using Linked List
3. Linked list implementation of Stack ADT
4. Linked list implementation of Queue ADT
5. Implementation of Binary Tree and Tree Traversals
6. Implementation of Binary Search Tree
7. Implementation of Dijkstra's Algorithm.
8. Implementation of Prim's Algorithm
9. Implementation of Linear Search and Binary Search
10. Implementation of Insertion Sort and Merge Sort

TOTAL: 45 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : DATA STRUCTURES USING C LABORATORY		**Course Code: 24EE6L2**	
CO	**Course Outcomes**	**Exp**	**K- CO**
CO1	Apply abstract data types and implement various algorithmic problems using arrays and linked list.	1,2	K3
CO2	Apply the different linear data structures like stack and queue to solve various computing problems.	3, 4	K3
CO3	Build different types of trees and apply various operations for tree manipulation.	5, 6	K3
CO4	Solve graph based problem using traversal techniques and path finding.	7,8	K3
CO5	Apply different sorting, searching and hashing techniques for data manipulation and storing.	9,10	K3

24EE6L3	MINI PROJECT-I	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To develop the students own innovative prototype ideas.
- To train the students in preparing mini project reports and examination.

The students in a group of 2 to 4 works on a topic approved by the head of the department and prepare a comprehensive mini project report after completing the work to the satisfaction. The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A mini project report is required at the end of the semester. The mini project work is evaluated based on oral presentation and the mini project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 60 PERIODS

OUTCOME:

- On Completion of the mini project work students will be in a position to take up their Final year project work and find solution by formulating proper methodology.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : MINI PROJECT-I		**Course Code : 24EE6L3**
CO	**Course Outcomes**	**K –CO**
CO1	Identify the real world and societal importance problems in the Electrical and its allied area.	K4
CO2	Identify, analyze, design, implement and handle prototype projects with a complete and organized solution methodologies	K4
CO3	Apply modern engineering tools for solution	K4
CO4	Contribute as an individual or in a team in development of technical projects	K4
CO5	Develop effective communication skills for presentation of project related activities, Prepare reports following professional ethics	K4

24HS6L1	PROGRAMMING SKILLS II	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To Develop logical reasoning and problem-solving ability to break down real-world tasks into structured computational steps.
- To Strengthen programming fundamentals including loops, conditionals, recursion, string manipulation, and mathematical operations.
- To Enhance algorithmic thinking for designing efficient solutions under given boundary condition and time limits.
- To Promote analytical skills to handle diverse problem domains like number theory, text processing, and data structures.
- To Encourage optimization and performance awareness by working within strict execution time and memory constraints

Sample problems

1. A positive integer N is passed as the input. If we print all the numbers from 1 to N continuously, the program must find the number of characters(digits) C printed and print the count C as the output.
2. Given a string S as input which consists of multiple words separated by a space, the program must print the count C of the words which are repeated exactly N times. The comparison of the words is case sensitive.
3. The program must accept the score of N players in a cricket match. The program must print the number of combinations with exactly 4 players and total runs scored by the 4 players is greater than or equal to 100as the output.
   Boundary Condition(s):4 <= N <= 250
4. Given N numbers, the program must print the first number F of the last non-decreasing subset sequence present.
5. Given a string S with only alphabets, print the alphabet and it's count as shown in the Example
6. The program must accept two integers N and X as the input. The program must print the number of subsets of N divisible by X as the output.
   Boundary Condition(s):1<=NX=10^18
7. A set of space separated integers are passed as the input. The program must replace the alternate duplicate integer values with zero. Then the program must print the revised set of integers as the output.
   Boundary Condition(s):1 <= Each integer value <= 10^5
8. Lalitha has three children. She wants to distribute N candies among all three in such a way that exactly one child gets the maximum number of candies among all three and each child gets at least one candy. The task is to find the total number of ways to distribute the N candies among the three children.
   Boundary Condition(s):3 < N <= 100
9. The program must accept a string $ as the input. The program must split the given string S into three substrings FRONT, MIDDLE and END based on the following conditions If the length of S is a multiple of 3, then each substring will contain 1/3 characters. If the remainder when the length of 5 is divided by 3 is 1, then the MIDDLE substring will contain that one extra character, If the remainder when the length of 5 is divided by 3 is 2, then each of the FRONT and END substrings will contain that one extra character
   Finally, the program must print the three substrings of S as the output

Boundary Condition(s): 3 <= Length of S <= 100

10. The program must accept N integers as the input. The program must print the maximum length of the subset whose sum of integers is a composite integer.
Boundary Condition(s):1<=N<=10,1 <= Each integer value <= 10^5

TOTAL: 30 PERIODS

REFERENCES:

1. https://skillrack.com/faces/candidate/codeprogram.xhtml
2. https://www.geeksforgeeks.org/blogs/how-to-approach-a-coding-problem/
3. https://leetcode.com/

Vertical – I – Modern Power System Engineering

24EEV11	POWER QUALITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various power quality issues.
- To understand the causes, impacts and mitigation of Voltage sag and interruptions in power system.
- To understand the causes, impacts and mitigation of over voltages in power system with PSCAD and EMTP.
- To understand the concept of harmonics in power system with their causes, effects and control techniques.
- To understand the various types of conventional and modern power quality monitoring devices/methods.

UNIT – I INTRODUCTION **9**

Terms and definitions – Overloading – Under voltage – Sustained interruption - Sags and Swells – Waveform distortion – Total Harmonic Distortion (THD) – Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT – II VOLTAGE SAGS AND INTERRUPTIONS **9**

Sources of sags and interruptions – Estimating voltage sag performance – Motor starting sags – Estimating the sag severity – Mitigation of voltage sags – Active series compensators – Static transfer switches and fast transfer switches.

UNIT – III OVERVOLTAGES **9**

Sources of over voltages – Capacitor switching – Lightning – Ferro resonance – Mitigation of voltage swells – Surge arresters – Low pass filters – Power conditioners – Lightning protection – Shielding – Line arresters – Protection of transformers and cables – Computer analysis tools for transients – PSCAD and EMTP.

UNIT – IV HARMONICS **9**

Harmonic distortion – Voltage and current distortion – Harmonic indices – Harmonic sources from commercial and industrial loads — Locating harmonic sources — Power system response characteristics – Resonance – Harmonic distortion evaluation – Devices for controlling harmonic distortion – Passive filters – Active filters – IEEE and IEC standards.

UNIT - V POWER QUALITY MONITORING AND CUSTOM POWER DEVIES **9**

Power line disturbance analyzer - Harmonic/Spectrum analyzer - Flicker meters - Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified power quality conditioner.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Roger C. Dugan, Surya Santoso, Mark F. McGranaghan, H. Wayne Beaty "Electrical Power Systems Quality", McGraw-Hill Education, 2002
2. A.J. Arrillga, "Power system harmonics", Wiley, 2003 (2nd edition)

REFERENCES:

1. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994 (2nd edition)
2. Derek A. Paice, "Power Electronic Converter Harmonics", Wiley-IEEE Press-I st Edition- 1999

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : POWER QUALITY		Course Code : 24EEV11	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Classify power quality disturbances, their causes, detrimental effects and Power quality standard.	I	K3
CO2	Illustrate the impact of voltage sag and interruptions in power systems.	II	K3
CO3	Analyze the over voltage phenomena using PSCAD and EMTP.	III	K4
CO4	Develop the impact of Harmonics in power systems.	IV	K3
CO5	Illustrate the different types of monitoring devices/methods for power quality in power system.	V	K3

24EEV21	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES: To impart knowledge about the following topics:

- Introduction to smart grid and compare this with conventional grid
- Smart Grid technologies both in transmission and distribution side
- Different smart meters and advanced metering infrastructure
- Power quality management issues in Smart Grid.
- The high performance computing for Smart Grid applications

UNIT - I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT - II SMART GRID TECHNOLOGIES (TRANSMISSION) 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control.

UNIT - III SMART GRID TECHNOLOGIES (DISTRIBUTION) 9

DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles (PHEV).

UNIT - IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure(AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED)&their application for monitoring & protection.

UNIT - V POWER QUALITY MANAGEMENT IN SMART GRID AND SMART GRID APPLICATIONS 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stuart Borlase “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press 2012.
2. Janaka Ekanayake, NickJ enkins, Kithsiri Liyanage, JianzhongWu, AkihikoYokoyama, “Smart Grid: Technology and Applications”, Wiley 2012.

REFERENCES:

1. VehbiC. Gungor ,Dilan Sahin, Taskin Kocak, Salih Ergut, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards” IEEE Transactions On Industrial Informatics,Vol.7,No.4, November 2011.
2. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang “SmartGrid –The New and Improved Power Grid: A Survey” ,IEEE Transaction on Smart Grids,vol.14,2012.
3. James Momohe “Smart Grid: Fundamentals of Design and Analysis,”, Wiley-IEEE Press , 2012.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : SMART GRID		Course Code : 24EEV21	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Classify the functions, opportunities, challenges and benefits of Smart Grid	I	K3
CO2	Illustrate the Smart energy resources and Transmission systems	II	K3
CO3	Develop the different Smart Grid distribution technologies	III	K3
CO4	Classify the function of different smart meters and advanced metering infrastructure.	IV	K3
CO5	Develop the power quality management in Smart Grids	V	K3

24EEV31	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES: To impart knowledge about the following topics:

- The start-of-art of the power system
- Performance of power systems with FACTS controllers.
- FACTS controllers for load flow and dynamic analysis

UNIT - I INTRODUCTION **9**

Real and reactive power control in electrical power transmission lines–loads & system compensation-Uncompensated transmission line–shunt and series compensation

UNIT - II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS **9**

Voltage control by SVC–Advantages of slope in dynamic characteristics–Influence of SVC on system voltage–Design of SVC voltage regulator–TCR-FC-TCR-Modeling of SVC for power flow and fast transient stability– Applications: Enhancement of transient stability –Steady state power transfer –Enhancement of power system damping.

UNIT - III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS **9**

Operation of the TCSC–Different modes of operation–Modelling of TCSC, Variability reactance model– Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit–Enhancement of system damping.

UNIT - IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS **9**

Static Synchronous Compensator (STATCOM)–Principle of operation–V-I Characteristics. Applications: Steady state power transfer-enhancement of transient stability-prevention of voltage instability. SSSC-operation of SSSC and the control of power flow–modelling of SSSC in load flow and transient stability studies- Dynamic voltage restorer (DVR).

UNIT - V ADVANCED FACTS CONTROLLERS **9**

Interline DVR (IDVR) - Unified Power flow controller (UPFC) - Interline power flow controller (IPFC) - Unified Power quality conditioner (UPQC).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R.Mohan Mathur, Rajiv K.Varma, “Thyristor–Based Facts Controllers for Electrical Transmission Systems”, IEEE press andJohnWiley&Sons,Inc,2002.
2. NarainG. Hingorani, “Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors,Delhi-110006,2011.
3. T.J.E Miller, Power Electronics in power systems, John Wiley and sons.

REFERENCES:

1. K.R. Padiyar, ”FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, Publishers, New Delhi, 2008
2. A.T.John, “Flexible A.C.Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
3. V.K.Sood, HVDC and FACTS controllers–Applications of Static Converters in Power System, APRIL2004, Kluwer Academic Publishers,2004.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: FLEXIBLE AC TRANSMISSION SYSTEMS		**Course Code: 24EEV31**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Develop analytical model of FACTS controller for power system application.	I	K3
CO2	Explain and Model the facts devices.	II	K3
CO3	Illustrate the start-of-art of the power system	III	K3
CO4	Develop the performance of steady state and transients of facts controllers.	IV	K3
CO5	Illustrate advanced FACTS controllers.	V	K3

24EEV41	ENERGY AUDITING AND MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES: To impart knowledge on the following Topics

- Awareness about importance of energy management and auditing.
- Understanding the Energy management on various electrical motors.
- Understanding the Energy management on electric lighting systems.
- Apply the different types of metering methods of energy management and auditing
- Provide the economic models for energy and load management.

UNIT - I INTRODUCTION **9**

Basics of Energy – Need for energy management – Energy accounting – Energy monitoring, targeting and reporting – Energy audit process.

UNIT - II ENERGY MANAGEMENT FOR MOTORS AND COGENERATION **9**

Energy management for electric motors – Transformer and reactors – Capacitors and synchronous machines, energy management by cogeneration – Forms of cogeneration – Feasibility of cogeneration – Electrical interconnection.

UNIT - III LIGHTING SYSTEMS **9**

Energy management in lighting systems – Task and the working space – Light sources – Ballasts – Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics, lighting and energy standards..

UNIT - IV METERING FOR ENERGY MANAGEMENT **9**

Metering for energy management – Units of measure – Utility meters – Demand meters – Paralleling of current transformers – Instrument transformer burdens – Multi tasking solid state meters, metering location vs requirements, metering techniques and practical examples.

UNIT - V ECONOMIC ANALYSIS AND MODELS **9**

Economic analysis – Economic models – Time value of money – Utility rate structures – Cost of electricity – Loss evaluation, load management – Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification.

TOTAL: 45PERIODS

TEXT BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
2. Eastop T. D & Croft D. R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.

REFERENCES:

1. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
3. Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.
4. Electricity in buildings good practice guide, McGraw-Hill Education, 2016.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ENERGY AUDITING AND MANAGEMENT		**Course Code : 24EEV41**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the importance of energy management and auditing.	I	K2
CO2	Describe energy management on different types of electrical equipment.	II	K3
CO3	Discuss the energy management on different types of lighting system and light sources.	III	K3
CO4	Describe the different types of metering methods of energy management and auditing.	IV	K4
CO5	Explain the economic models for energy and load management.	V	K2

24EEV51	HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Causes of over voltages in Power System and protection methods.
- Breakdown phenomenon in Gas, Liquid, Vacuum, Solid and Composite Dielectrics
- Generation of high AC& DC voltages and Impulse voltage & Current.
- Various methods of measurement of High Voltages and Currents.
- Testing of power apparatus and insulation coordination

UNIT-I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS 9

Introduction to over voltages - Natural Causes of over voltages - Charge formation in the clouds — Lightning phenomenon: Mechanism of lightning stroke, Mathematical modeling of lightning - Switching surges- Reflection and Refraction of Travelling waves- Protection against over voltages.

UNIT-II ELECTRICAL BREAKDOWN IN GAS, LIQUID and SOLID DIELECTRICS9

Gaseous breakdown - Uniform field - Townsend criterion, Streamer theory - Pachen's law - Non-uniform fields - Corona discharges - Vacuum breakdown - Conduction and breakdown in pure and commercial liquids - Breakdown mechanisms in solid dielectrics.

UNIT-III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS 9

Generation of High DC Voltages: Voltage doubler, Cockcroft Walton Voltage multiplier and Vande- Graff generator- Generation of high AC voltages: Cascaded transformer, Resonant transformer, and Tesla coil -Generation of Impulse voltage: Single and Multistage impulse generator - MARX circuit and generation of impulse current - Tripping and control of impulse generators.

UNIT- IV MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS 9

High Resistance with series ammeter - Dividers, Resistance, Capacitance and Mixed dividers - Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers, Electrostatic Voltmeters - Sphere Gaps - High current shunts- Digital techniques in high voltage measurement. **UNIT-V HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS 9**

Terminologies and Definitions - High voltage testing of electrical power apparatus as per standards: Insulators, Bushings, Isolators, Circuit Breakers, Cables, Transformers, and Surge Arrester - Insulation Coordination.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Naidu M.S. and Kamaraju V., "High Voltage Engineering", McGraw Hill, 6th Edition, 2020.
2. Wadhwa C.L., "High Voltage Engineering'', New age publishers, 3rd Edition, 2012.
3. Kuffel E. and Zaengl W.S., "High Voltage Engineering Fundamentals", Pergamon press, Oxford, London, 2005.

REFERENCES:

1. L.L. Alston, 'High Voltage Technology', Oxford University Press, First Indian Edition,2011.
2. Mazen Abdel – Salam, Hussein Anis, Ahdab A-Morshedy, Roshday Radwan, High Voltage Engineering – Theory &Practice, Second Edition Marcel Dekker, Inc., 2010
3. Subir Ray,' An Introduction to High Voltage Engineering' PHI Learning Private Limited, New Delhi, Second Edition, 2013.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: HIGH VOLTAGE ENGINEERING		**Course Code : 24EEV51**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Identify the causes of over voltage and its effects in power system.	I	K3
CO2	Explain the breakdown Mechanisms in Solid, Liquid, gases and Composite dielectrics.	II	K3
CO3	Analyze different type of Generating circuit for high voltage D.C and high voltage A.C.	III	K4
CO4	Explain the Measurement of A.C and D.C high voltage and current using appropriate method.	IV	K3
CO5	Analyze the importance of power apparatus testing in Transient studies.	V	K4

24EEV61	ELECTRIC ENERGY GENERATION, UTILIZATION AND CONSERVATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To discuss the various sources of power generation.
- To understand the principle, design of illumination systems and energy efficiency lamps.
- To explain the various methods of industrial heating and welding.
- To Analyze the behavior & control of electric traction system.
- To understand the principle of Refrigerator and Air Conditioner.

UNIT I POWER GENERATION 9

Review of conventional methods – thermal, hydro and nuclear based power generation. Non- conventional methods of power generation – fuel cells - tidal waves – wind – geothermal – solar - bio- mass - municipal waste. Cogeneration. Effect of distributed generation on power system operation

UNIT II ILLUMINATION ENGINEERING 9

Nature of radiation – definition – laws of illumination – lighting calculations – design of illumination systems – residential, industrial, commercial, flood lighting and street lighting – types of lamps – energy efficient lamps

UNIT III HEATING AND WELDING 9

Role electric heating for industrial applications – Requirement of heating material – Design of heating element – Methods of heating: Resistance heating – Induction heating – Dielectric heating – Methods of welding: Resistance welding – Arc welding – welding generator, welding transformer and the characteristics.

UNIT IV ELECTRIC DRIVES AND TRACTION 9

Fundamentals of electric drive - choice of an electric motor - application of motors for particular services - traction motors - characteristic features of traction motor - systems of railway electrification - electric braking - train movement and energy consumption - traction motor control - track equipment and collection gear.

UNIT V REFRIGERATION AND AIR CONDITIONING 9

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air- conditioning system and their applications, smart air conditioning units – Energy Efficient motors: Standard motor efficiency, need for efficient motors.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Wadhwa, C.L., Generation, Distribution and Utilization of Electrical Energy, New Academic Science, 2011.
2. Gupta, B.R., Generation of Electrical Energy, Eurasia Publishing House (P) Ltd, New Delhi, 2003.
3. S. Sivanagaraju, M. Balasubba Reddy, D. Srilatha,' Generation and Utilization of Electrical Energy', Pearson Education, 2010.

REFERENCES:

1. Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 15th Edition, 2014.
2. H.Partab, Art and Science of Utilisation of Electrical Energy", Dhanpat Rai and Co., New Delhi, 2004.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: Electric Energy Generation, Utilization and Conservation		**Course Code: 24EEV61**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe the basic principles & technologies of various renewable and nonrenewable energy resource-based power generation	I	K3
CO2	Categorize different light sources and design various illumination systems for the indoor lighting schemes, factory lighting, halls, outdoor lighting schemes, flood lighting, street lighting	II	K4
CO3	Classify different methods of electric heating and electric welding in industries.	III	K3
CO4	Compute the tractive effort for the propulsion of train, name the traction motors, list the traction motor control, track equipment and collection gear.	IV	K3
CO5	Explain the concept of Air conditioner and refrigerator.	V	K3

Vertical – II – Power Electronics Converters and Drives

24EEV12	MODERN POWER CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on the Switched mode power supplies.
- To understand the performance analysis and operation of the AC to DC converter and DC to AC converter.
- To study the concept of Matrix Converter.
- To introduce the Soft switched converters.
- To impart knowledge on the Switched mode power supplies.

UNIT – I SWITCHED MODE POWER SUPPLIES (SMPS) 9

DC Power supplies and Classification - Switched mode dc power supplies - with and without isolation - single and multiple outputs - Closed loop control and regulation - Design examples on converter and closed loop performance.

UNIT – II AC-DC CONVERTERS 9

Switched mode AC-DC converters - Synchronous rectification - single and three phase topologies - switching techniques - high input power factor - Reduced input current harmonic distortion - Improved efficiency - with and without input-output isolation - Performance indices design examples.

UNIT – III DC-AC CONVERTERS 9

Multi-level Inversion – concept - classification of multilevel inverters - Principle of operation - main features and analysis of Diode clamped - Flying capacitor and cascaded multilevel inverters - Modulation schemes.

UNIT – IV AC-AC CONVERTERS WITH AND WITHOUT DC LINK 9

Matrix converters - Basic topology of matrix converter - Commutation — current path - Modulation techniques - scalar modulation - indirect modulation - Matrix converter as only AC-DC converter - AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter - Performance comparison with matrix converter with DC link converters.

UNIT – V SOFT-SWITCHING POWER CONVERTERS 9

Soft switching techniques – ZVS – ZCS - quasi resonance operation - Performance comparison hard switched and soft switched converters - AC-DC converter - DC-DC converter - DC-AC converter - Resonant DC power supplies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ned Mohan, T.M Undeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
2. M.H.Rashid, ‘Power Electronics Handbook’, Academic press, New York, 2001.

REFERENCES:

1. Frede Blaabjerg and Zhe Chen, ‘Power Electronics for Modern Wind Turbines’, Morgan and Claypool Publishers series, United States of America, 2006.
2. Agarwal, ’Power Electronics: Converters, Applications, and Design’, 3rd edition, Jai P,Prentice Hall, 2000.
3. L. Umanand, ‘Power Electronics: Essentials & Applications’, John Wiley and Sons, 2009.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: MODERN POWER CONVERTERS		Course Code : 24EEV12	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the concepts and working of Switched mode dc power supplies.	I	K3
CO2	Explain the various AC-DC power converter circuits and their switching techniques.	II	K3
CO3	Analyze various types of DC-AC power converter circuits.	III	K4
CO4	Design various basic topology of Matrix converter.	IV	K3
CO5	Describe the operating principle of soft switching power converter and compare various types of Soft Switched Power converters.	V	K3

24EEV22	SPECIAL ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the characteristics and modes of excitation of stepper motor.
- To understand the power controllers and the modes of operation of switched reluctance motor.
- To understand the construction and principle of operation of permanent magnet brushless dc motor.
- To understand the power controller circuit for permanent magnet synchronous motor.
- To understand the construction and principle of operation of synchronous reluctance motor.

UNIT - I STEPPER MOTOR **9**

Construction and Principle of operation - Variable reluctance stepper motor - Permanent magnet stepper motor - Hybrid stepper motor - Static and dynamic characteristics - Driver circuit - Applications and advantages.

UNIT - II SWITCHED RELUCTANCE MOTORS **9**

Constructional features - Principle of operation - Torque equation - Power controllers - Control circuits for SRM - Torque speed Characteristics - Microprocessor based controller.

UNIT - III PERMANENT MAGNET BRUSHLESS DC MOTOR **9**

Permanent Magnet materials - Characteristics - construction and principle of operation - Types - Difference between mechanical and electronic commutators - EMF and torque equations - torque speed characteristics - Hall sensors - optical position sensors - Microprocessor Based controller. **UNIT - IV**

PERMANENT MAGNET SYNCHRONOUS MOTOR **9**

Principle of operation - EMF and Torque equations - self-control - vector control - Torque speed Characteristics - Microprocessor based control – Applications.

UNIT - V SYNCHRONOUS RELUCTANCE MOTORS **9**

Construction and operating principle - Axial and radial air gap motors - Phasor diagram - Voltage and torque equation - Characteristics and its Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. K.Venkataratnam, ‘Special Electrical Machines’, Universities Press (India) Private Limited, 2008.
2. T. Kenjo, ‘Stepping Motors and Their Microprocessor Controls’, Clarendon Press London, 2009

REFERENCES:

1. Kenjo T and Nagamori S, ‘Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1986.
2. R.Krishnan, ‘Switched Reluctance Motor Drives - Modeling, Simulation, Analysis, Design and Application’, CRC Press, New York, 2014.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: SPECIAL ELECTRICAL MACHINES		Course Code: 24EEV22	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the construction and Principle of operation of stepper motor	I	K3
CO2	Discuss the construction and Principle of operation of SRM	II	K3
CO3	Describe the construction and Principle of operation of Permanent Magnet Brushless DC Motor	III	K3
CO4	Discuss the Principle of operation of Permanent Magnet Synchronous Motor	IV	K3
CO5	Describe the construction and Principle of operation of Synchronous Reluctance Motors	V	K3

24EEV32	SOLID STATE DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the basic knowledge of Electrical Drives.
- To analyze the operation of controlled rectifier.
- To analyze the operation of chopper fed DC Drives.
- To study and understand the operation and performance of Induction motor drives.
- To study and understand the operation and performance of synchronous motor drives.

UNIT - I DRIVE CHARACTERISTICS 9

Introduction : drive system, types, choice of electrical drives; Dynamics of electrical drives - fundamental torque equation, multi-quadrant operation, equivalent values of drive parameters, components of load torques, classification of load torques, steady state stability, modes of operation.

UNIT - II DC MOTOR DRIVES 9

DC motor Fundamental relations – Steady state analysis of single phase semi converter, single phase and three phase full converter fed separately excited DC motor drive –continuous conduction – Time ratio and current limit control – chopper fed dc motor drives - single, two and 4 quadrant operations.

UNIT - III INDUCTION MOTOR DRIVES 9

Speed control — Stator control: Stator Voltage Control — Constant voltage variable frequency operation - V/f control - VSI and CSI fed induction motor drives and Closed loop control - Rotor control: Rotor resistance control - Qualitative treatment of slip power recovery scheme — Introduction to Vector Controlled Induction Motor Drives.

UNIT - IV SYNCHRONOUS MOTOR DRIVES 9

Speed control - V/f control - separate and self-control of synchronous motor drives using load commutated thyristor inverter - Margin angle control and power factor control - Permanent magnet AC motor drives - Applications.

UNIT - V DESIGN OF CONTROLLERS FOR DC DRIVES 9

Transfer function of separately excited DC motors / load and converter - Closed loop control of armature and field weakening control - Design of controllers: Current controller and speed controller

- Converter selection and characteristics - Microprocessor/ Microcontroller based control of drives.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gopal K.Dubey, ‘Fundamentals of Electrical Drives’, Narosa Publishing House, Second Edition, 2015.
2. Krishnan R., ‘Electric Motor & Drives: Modelling, Analysis and Control’, Pearson Education, 2015

REFERENCES:

1. Bimal K Bose, ‘Modern Power Electronics and AC Drives’, Pearson Education, 2016.
2. Vedam Subramanyam, ‘Electric Drives – Concepts and Applications’, McGraw Hill, Second Edition, 2010
3. Pillai S.K., ‘A First Course on Electrical Drives’, New Age International Publishers, Third Edition, 2013.
4. Muhammad H. Rashid, ‘Power Electronics: Circuits, Devices and Applications’, Pearson Education, 4th Edition, 2017.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: SOLID STATE DRIVES		Course Code: 24EEV32	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the basics and importance of electric drives.	I	K3
CO2	Describe the operation of the various Chopper fed separately excited dc motor drives.	II	K3
CO3	Explain the various solid state speed control methods of induction motor drives.	III	K3
CO4	Discuss the various speed control methods of synchronous motor drives and applications.	IV	K3
CO5	Apply the knowledge of Electrical Engineering fundamentals to develop current and speed controllers for a closed loop solid state dc motor drive.	V	K3

24EEV42	CONTROL OF ELECTRICAL DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the DC drive control.
- To study and analyze the Induction motor drive control.
- To study and understand the Synchronous motor drive control.
- To study and analyze the SRM and BLDC motor drive control.
- To analyze and design the Digital control for drives.

UNIT - I CONTROL OF DC DRIVES 9

Losses in electrical drive system, Energy efficient operation of drives, block diagram /transfer function of self, separately excited DC motors --closed loop control-speed control current control - constant torque/power operation - P, PI and PID controllers– response Comparison.

UNIT - II CONTROL OF INDUCTION MOTOR DRIVE 9

VSI and CSI fed induction motor drives-principles of V/f control-closed loop variable frequency PWM inverter with dynamic braking- static Scherbius drives- power factor considerations– modified Kramer drives-principle of vector control- implementation-block diagram, Design of closed loop operation of V/f control of Induction motor drive systems.

UNIT - III CONTROL OF SYNCHRONOUS MOTOR DRIVES 9

Open loop VSI fed drive and its characteristics–Self-control–Torque control –Torque angle Control –Power factor control–Brushless excitation systems—Field oriented control –Design of closed loop operation of Self-control of Synchronous motor drive systems.

UNIT - IV CONTROL OF SRM AND BLDC MOTOR DRIVES 9

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux Controllers - Construction and Principle of operation of BLDC Machine -Sensing and logic switching scheme,- Sinusoidal and trapezoidal type of Brushless dc motors — Block diagram of current controlled Brushless dc motor drive.

UNIT - V DIGITAL CONTROL OF DC DRIVE 9

Phase Locked Loop and micro-computer control of DC drives–Program flow chart for constant constant torque and constant horse power operations Speed detection and current sensing circuits and feedback elements.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gopal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, Second Edition, 2015.
2. Krishnan R., " Electric Motor & Drives: Modelling, Analysis and Control", Pearson Education, 2015

REFERENCES:

1. Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press
2. Bimal K Bose, "Modern Power Electronics and AC Drives" Pearson Education, 2016.
3. R. Krishnan, Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications, CRC press, 2001.
4. Werner Leonhard, Control of Electrical Drives, 3rd Edition, Springer, Sept., 2001.
5. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC press, 2001.
6. Murphy, J.M.D, Turnbull F.G, Thyristor control of AC motors,., Pergamon press, Oxford, 1988

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: CONTROL OF ELECTRICAL DRIVES		Course Code: 24EEV42	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the various control strategies and controllers for DC Motor Drive systems.	I	K3
CO2	Discuss the various control strategies and controllers for Induction Motor Drive systems and develop the closed loop operation of V/f control of Induction motor drive systems.	II	K3
CO3	Describe the various control strategies and controllers for Synchronous Motor Drive systems.	III	K3
CO4	Discuss the various control strategies and controllers for BLDC Motor Drive systems.	IV	K3
CO5	Explain the various Digital control for DC Motor Drive systems.	V	K3

24EEV52	SMPS AND UPS	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge about the following topics:

- Modern power electronic converters and its applications in electric power utility.
- Resonant converters and UPS

UNIT - I DC-DC CONVERTERS 9

Principles of step down and step up converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and Cuk converters.

UNIT - II SWITCHED MODEPOWER CONVERTERS 9

Analysis and state space modeling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters - control circuits and PWM techniques.

UNIT - III RESONANTCONVERTERS 9

Introduction – classification - basic concepts - Resonant switch - Load Resonant converters - ZVS, Clamped voltage topologies - DC link inverters with Zero Voltage Switching - Series and parallel Resonant inverters - Voltage control.

UNIT - IV DC-AC CONVERTERS 9

Single phase and three phase inverters, control using various (sine PWM, SVPWM and PSPWM) techniques, various harmonic elimination techniques - Multilevel inverters - Concepts - Types: Diode clamped - Flying capacitor - Cascaded types - Applications.

UNIT - V V POWER CONDITIONERS, UPS& FILTERS 9

Introduction - Power line disturbances - Power conditioners — UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for PE applications — Selection of capacitors.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Simon Ang, Alejandro Oliva," Power-Switching Converters", Third Edition, CRC Press, 2010.
2. Kjeld Thorborg, "Power Electronics – In theory and Practice", Overseas Press, First Indian Edition2005.
3. M.H. Rashid – Power Electronics handbook, Elsevier Publication,2001

REFERENCES:

1. Philip T Krein, " Elements of Power Electronics", Oxford University Press
2. Ned Mohan, Tore.M.Undel and, William. P.Robbins, Power Electronics converters, Applications and design- Third Edition- John Wiley and Sons- 2006
3. M.H. Rashid – Power Electronics circuits, devices and applications-third edition Prentice Hall of India New Delhi, 2007.
4. Erickson, Robert W, "Fundamentals of Power Electronics", Springer, second edition, 2010.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: SMPS AND UPS		**Course Code :24EEV52**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the operation and state space modeling of DC-DC converters	I	K3
CO2	Describe the operation and state space modeling of switched mode power converters	II	K3
CO3	Discuss the basic concept and operation of resonant converters	III	K3
CO4	Summarize the PWM techniques for DC-AC converters	IV	K3
CO5	Explain the operation of Power conditioners, UPS and its applications in electric power utility.	V	K3

24EEV62	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES: To impart knowledge on the following Topics

- To learn the various types of renewable sources of energy.
- To understand the electrical machines to be used for wind energy conversion systems.
- To learn the principles of power converters used in solar PV system.
- To study the principle of power converters used in Wind system.
- To simulate the AC-DC, AC-AC Converters, Matrix Converters and PWM Inverters.

UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 9

Classification of Energy Sources — Importance of Non-conventional energy sources — Advantages and disadvantages of conventional energy sources-Environmental aspects of energy — Impacts of renewable energy generation on the environment-Qualitative study of renewable energy resources: Ocean energy, Bio-mass energy, Hydrogen energy-Solar Photovoltaic (PV),Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS 9

Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG)-Permanent Magnet Synchronous Generator (PMSG).

UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS 9

Power Converters: Line commutated converters (inversion-mode)-Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Simulation of line commutated converters, buck/boost converters. Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems - Grid Connection Issues.

UNIT IV POWER CONVERTERS FOR WIND SYSTEMS 9

Power Converters: Three-phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters- Matrix converter.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems - Range and type of Hybrid systems - Case studies of Diesel - PV, Wind - PV, Micro hydel - PV, Biomass - Diesel systems - Maximum Power Point Tracking (MPPT).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S.N.Bhadra, D.Kastha, & S.Banerjee “Wind Electrical Systems”, Oxford University Press, 2009, 7th impression
2. Rai.G.D, ”Solar energy utilization”, Khanna publishers, 5th Edition, 2008
3. Rai G.D., Non-Conventional Energy Sources, Khanna Publishers, 2011.

REFERENCES:

1. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Private Limited, New Delhi, 2011
2. Godfrey Boyle, “Renewable energy”, Open University, Oxford University Press in association with the Open University, 2004.
3. Shobh Nath Singh, ‘Non-conventional Energy resources’ Pearson Education, 2015.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : Power Electronics for Renewable Energy Systems		Course Code :24EEV62	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Discuss the various types of renewable energy sources	I	K3
CO2	Analyze the performance of IG,PMSG,SCIG AND DFIG	II	K4
CO3	Analyze different power converters namely AC to DC,DC to DC and Ac to AC converters for renewable energy sources	III	K4
CO4	Analyze various operating modes of solar energy systems	IV	K4
CO5	Develop maximum power point tracking algorithms	V	K4

24EEV72	ELECTRICAL MACHINE DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Magnetic circuit parameters and thermal rating of various types of electrical machines.
- Armature and field systems for D.C. machines.
- Core, yoke, windings and cooling systems of transformers.
- Design of stator and rotor of induction machines.
- Design of stator and rotor of synchronous machines.

UNIT-I DESIGN OF FIELD SYSTEM AND ARMATURE 9

Major considerations in Electrical Machine Design – Design factors-Limitations in Design-Electrical Engineering materials –Design of Magnetic circuits — Magnetizing current — Flux leakage — Leakage in Armature - Design of lap winding and wave winding

UNIT-II DESIGN OF TRANSFORMERS 9

Construction - KVA output for single and three phase transformers – Overall dimensions design of yoke, core and winding for core and shell type transformers — Estimation of No load current – Temperature rise in Transformers – Design of Tank and cooling tubes of Transformers. Computer program: Complete Design of single phase core type transformer.

UNIT-III DESIGN OF DC MACHINES 9

Construction - Output Equations – Main Dimensions – Choice of specific loadings – Selection of number of poles — Design of Armature — Design of commutator and brushes design of field - Computer program: Design of Armature main dimensions.

UNIT- IV DESIGN OF INDUCTION MOTORS 9

Construction - Output equation of Induction motor – Main dimensions – choice of specific loadings — Design of squirrel cage rotor and wound rotor –Magnetic leakage calculations –Operating characteristics : Magnetizing current - Short circuit current — Circle diagram -Computer program: Design of slip-ring rotor

UNIT- V DESIGN OF SYNCHRONOUS MACHINES 9

Output equation – choice of specific loadings – Design of salient pole machines – Shortcircuit ratio – Armature design – Estimation of air gap length – Design of rotor – Design of damper winding – Determination of full load field MMF – Design of turbo alternators -Computer program: Design of Stator main dimensions.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sawhney, A.K., 'A Course in Electrical Machine Design', Dhanpat Rai & Sons, New Delhi, Fifth Edition, 2016.
2. M V Deshpande 'Design and Testing of Electrical Machines' PHI learning Pvt Lt, 2011.
3. Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2009.

REFERENCES:

1. A.Shanmugasundaram, G.Gangadharan, R.Palani 'Electrical Machine Design Data Book', New Age International Pvt. Ltd., Reprint 2007.
2. Balbir Singh, 'Electrical Machine Design', Vikas Publishing House Private Limited, 1981.
3. V Rajini, V.S Nagarajan, 'Electrical Machine Design', Pearson, 2017.
4. K.M.Vishnumurthy, 'Computer aided design of electrical machines', BSPublications, 2008.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ELECTRICAL MACHINE DESIGN		**Course Code :24EEV72**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the design considerations for rotating and static electrical machines.	I	K3
CO2	Analyze the design parameters of single and three phase transformer.	II	K4
CO3	Design armature and field of DC machines.	III	K3
CO4	Design stator and rotor of induction motor.	IV	K3
CO5	Design stator and rotor of synchronous machines.	V	K3

Vertical – III – Electric Vehicle Technology

24EEV13	POWER ELECTRONIC CONVERTERS FOR ELECTRIC VEHICLE	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of Power electronic devices
- To study the operation, switching techniques and basics topologies of DC-DC Converter.
- To understand the operation of Controlled rectifiers and Inverters that can be used in electric vehicles
- To understand the operation of Power electronic based drives that can be used in electric vehicles
- To understand the control of hybrid and fuel cell vehicles.

UNIT I BASIC POWER ELECTRONIC DEVICES **9**

Diodes – Thyristors - Bipolar Junction Transistors – Metal Oxide Semiconductor Field Effect Transistors - Insulated Gate Bipolar Transistors - Ultra capacitors.

UNIT II DC/DC CONVERTER **9**

Basic Principle of DC–DC Converter - Step-Down (Buck) Converter - Step-Up (Boost) Converter - Buck–Boost Converter - DC–DC Converters Applied in Hybrid Vehicle Systems - Isolated Buck DC–DC Converter - Four-Quadrant DC–DC Converter.

UNIT III RECTIFIERS AND INVERTERS **9**

Single-phase Diode Rectifiers - Three-phase Diode Rectifiers - Poly-phase Diode Rectifiers - Filtering Systems in Rectifier Circuits - High-frequency Diode Rectifier Circuits - Single-phase Voltage Source Inverters - Three-phase Voltage Source Inverters - Current Source Inverters - Closed-loop Operation of Inverters - Regeneration in Inverters - Multistage Inverters.

UNIT IV ELECTRIC MOTOR DRIVES **9**

DC motor speed control and braking - Chopper control based ac motor drives - cyclo-converter fed ac motor drives - slip power recovery scheme - four quadrant operation of electric drives.

UNIT V CONTROL OF HYBRID AND FUEL CELL VEHICLES **9**

Fuel Cell Vehicles - Power Electronics Requirements - Propulsion Motor Control Strategies - APU Control System in Series Hybrid Vehicles - Fuel Cell for APU Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, Third Edition, 2019
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, Taylor & Francis Group, Third Edition 2021.

REFERENCES:

1. “Power Electronics”, P.S.Bimbhra, Khanna publications, 2020.
2. “Thyristorised Power Controllers”, G.K.Dubey, New Age international publishers, 2019.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : Power Electronic Converters for Electric Vehicle		**Course Code : 24EEV13**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the basics of various power electronics devices suitable for electric vehicles.	I	K3
CO2	Explain the operation of DC-DC Converters used in electric vehicles	II	K3
CO3	Explain the operation of rectifiers and inverters used in electric vehicles	III	K3
CO4	Explain the various DC and AC motor drives suitable for EV	IV	K3
CO5	Explain the Electric Propulsion unit of Electric vehicles	V	K3

24EEV23	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To compare the concept of EV with hybrid and conventional Electric vehicles
- To understand the need of power electronics converters control in DC and AC drives.
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles
- To discuss alternative energy storage systems.

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 9

Architecture of EV's and HEV's – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT III CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

UNIT IV BATTERY ENERGYSTORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Mathematical modeling of lead acid Batteries, Traction Batteries.

UNIT V ALTERNATIVE ENERGYSTORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals" CRC Press, Taylor & Francis Group, Second Edition, 2016.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, Third Edition, 2019.

REFERENCES:

1. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010
2. Simona Onori, Lorenzo Serrao, "Hybrid Electric Vehicles Energy Management Strategies", Springer, 2015
3. Xiong, Rui, "Battery Management Algorithm for Electric Vehicles", Springer, 2020.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ELECTRIC VEHICLES AND POWER MANAGEMENT		**Course Code: 24EEV23**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Demonstrate the operation of Electric vehicles and various energy storage technologies for electrical vehicles	I	K3
CO2	Explain the Architecture of EV's and Power Train Components	II	K3
CO3	Discuss the Control of DC and AC drives	III	K3
CO4	Explain about various types of Battery energy storage system	IV	K3
CO5	Generalize the Alternative energy storage system	V	K3

24EEV33 ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

- To learn the basics of EV and vehicle mechanics
- To know the EV architecture
- To study the energy storage system concepts
- To derive model for batteries and to know the different types of batteries and its charging methods
- To learn the control preliminaries for DC-DC converters.

UNIT I INTERNAL COMBUSTION ENGINES 9

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions

UNIT II ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings-Comparisons of EV with internal combustion Engine vehicles – Fundamentals of vehicle mechanics.

UNIT III BATTERY MODELING, TYPES AND CHARGING 9

Batteries in Electric and Hybrid Vehicles - Battery Basics - Battery Parameters. Types - Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (NiMH) Battery - Li-Ion Battery Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal Chloride, Research and Development for Advanced Batteries. Battery Modelling, Electric Circuit Models. Battery Pack Management, Battery Charging.

UNIT IV CONTROL PRELIMINARIES 9

Control Design Preliminaries - Introduction - Transfer Functions - Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter – Gain margin and Phase margin study -
open loop mode.

UNIT V CONTROL OF AC MACHINES 9

Introduction - Reference frame theory, basics-modeling of induction and synchronous machine in various frames – Vector control – Direct torque control.

TOTAL: 45 PERIODS

Text Books:

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Power Electronic Converters, : Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley-VCH.

REFERENCES:

1. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall, 1997, 1st Edition.
2. Electrical Machine Fundamentals with Numerical Simulation using MATLAB / SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL		**Course Code: 24EEV33**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe the concepts related with EV, HEV and to compare the same with internal combustion engine vehicles.	I	K3
CO2	Discuss the fundamentals of vehicle mechanics	II	K3
CO3	Demonstrate the battery and to study the research and development for batteries	III	K3
CO4	Determine the gain margin & phase margin for various types of transfer functions of boost converter	IV	K3
CO5	Demonstrate the Control of AC Machines	V	K3

24EEV43	BATTERY MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To understand the different types of energy storage system.
- To study about the battery characteristic & parameters
- To model the types of batteries
- To know the concepts of battery management system and design the battery pack.
- To study about the battery testing, disposal and recycling

UNIT - I ENERGY STORAGE SYSTEM 9

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System **Suggested reading**: Study of different types of batteries

UNIT - II BATTERY CHARACTERISTICS & PARAMETERS 9

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

UNIT - III BATTERY MODELLING 9

Approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable Ni Cd battery, Parameterization of the Ni Cd battery model, Simulation examples

UNIT - IV BATTERY PACK AND BATTERY MANAGEMENT SYSTEM 9

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

UNIT - V BATTERY TESTING, DISPOSAL & RECYCLING 9

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric Hybrid Electric and Fuel Cell Vehicles”, Taylor& Francis Group, 2010.
2. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.

REFERENCES:

1. Guangjin Zhao, “Reuse and Recycling of Lithium-Ion Power Batteries”, John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
2. Arno Kwade, Jan Diekmann, “Recycling of Lithium-Ion Batteries: The LithoRec Way”, Springer, 2018. (ISBN: 978-3-319-70571-2)

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : BATTERY MANAGEMENT SYSTEM		**Course Code : 24EEV43**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Discuss about the different types of energy storage system.	I	K3
CO2	Describe about the battery characteristic & parameters.	II	K3
CO3	Explain the different types of batteries.	III	K3
CO4	Explain the concepts of battery management system	IV	K3
CO5	Explain about the battery testing, disposal and recycling.	V	K3

24EEV53	TESTING OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know various standardization procedures
- To learn the testing procedures for EV & HEV components
- To know the functional safety and EMC
- To realize the effect of EMC in EVs
- To study the effect of EMI in motor drives and in DC-DC converter system

UNIT - I EV STANDARDIZATION 9

Introduction – Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission – Standardization of Vehicle Components

UNIT - II TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES 9

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only).- Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

UNIT - III FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC 9

Functional safety life cycle — Fault tree analysis — Hazard and risk assessment — software development – Process models – Development assessments –Configuration management – Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality – Standards – Functional safety of autonomous vehicles.

UNIT - IV EMC IN ELECTRIC VEHICLES 9

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC — DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements

UNIT - V EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM 9

Overview - EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition.
2. Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition.

REFERENCES:

1. EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET2018, 1st Edition.
2. EMI/EMC Computational Modeling Handbook, Druce Archambeault, colinbranch, Omar M.Ramachi Springer 2012, 2nd Edition.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : TESTING OF ELECTRIC VEHICLES		**Course Code :24EEV53**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe the status and other details of standardization of EVs	I	K3
CO2	Illustrate the testing protocols for EVs and HEV components	II	K3
CO3	Explain the safety cycle and need for functions safety for EVs	III	K3
CO4	Discuss the problems related with EMC for EV components.	IV	K3
CO5	Determine the EMI in motor drive	V	K3

24EEV63	GRID INTEGRATION OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the basic details of V2G
- To study the benefits & challenges of V2G
- To learn EV & V2G on the smart grids renewable energy systems
- To know the grid integration

UNIT - I DEFINITION, And STATUS of V2G 9

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice, V2G - Power Markets and Applications. Electricity Markets and V2G Suitability, Long-Term Storage, Renewable Energy, and Other Grid Applications, Beyond the Grid: Other Concepts Related to V2G.

UNIT - II BENEFITS AND CHALLENGES OF V2G 9

Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.

UNIT - III CHALLENGES TO V2G 9

Technical Challenges - Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. The Economic and Business Challenges to V2G - Evaluating V2G Costs and Revenues , EV Costs and Benefits , Adding V2G Costs and Benefits Additional V2G Costs , The Evolving Nature of V2G Costs and Benefits. Regulatory and Political Challenges to V2G, V2G and Regulatory Frameworks, Market Design Challenges, Other V2G Regulatory and Legal Challenges

UNIT - IV IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS 9

Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

UNIT - V GRID INTEGRATION AND MANAGEMENT OF EVS 9

Introduction - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer,2015, 1st Edition.

REFERENCES:

2. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor; Jesus Fraile- Ardanuy, IET 2020, 1st Edition.
3. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
4. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle- to-Grid A Socio-technical Transition Beyond Electric Mobility, 2019, 1st Edition.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : GRID INTEGRATION OF ELECTRIC VEHICLES		**Course Code :24EEV63**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the concepts related with V2G	I	K3
CO2	Discuss the grid connection of 3 phase Q inverter	II	K3
CO3	Explain the technical, economics. business, regulatory & political challenges related with V2G	III	K3
CO4	Demonstrate the impact of EV and V2G on smart grid system	IV	K3
CO5	Explain the concept of grid integration and management of EVs	V	K3

Vertical – IV – Embedded System and VLSI Technology

24EEV14	LOW POWER IC DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

The main objectives of this course are to:

- To learn the fundamentals of low power low voltage VLSI design.
- To understand the impact of power on system performances.
- To understand the different design approaches.
- To develop the low power Multipliers
- To develop the low power low voltage memories.

UNIT I Fundamentals of Low Power Circuits 9

Need for Low Power Circuit Design, Sources of Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation, Short Channel Effects –Drain Induced Barrier Lowering and Punch Through, Surface Scattering, Velocity Saturation, Impact Ionization, Hot Electron Effect

UNIT II Low-Power Design Approaches 9

Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Architectural Level Approach –Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches: System Level Measures, Circuit Level Measures, Mask level Measures

UNIT III Low-Voltage Low-Power Adders 9

Introduction, Standard Adder Cells, CMOS Adder's Architectures – Ripple Carry Adders, Carry Look-Ahead Adders, Carry Select Adders, Carry Save Adders, Low Voltage Low Power Design Techniques – Trends of Technology and Power Supply Voltage, Low Voltage Low-Power Logic Styles.

UNIT IV Low-Voltage Low-Power Multipliers 9

Introduction, Overview of Multiplication, Types of Multiplier Architectures, Braun Multiplier, Baugh Wooley Multiplier, Booth Multiplier, Introduction to Wallace Tree Multiplier

UNIT V Low-Voltage Low-Power Memories 9

Basics of ROM, Low-Power ROM Technology, Future Trend and Development of ROMs, Basics of SRAM, Memory Cell, Pre-charge and Equalization Circuit, Low Power SRAM Technologies, Basics of DRAM, Self- Refresh Circuit, Future Trend and Development of DRAM.

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TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sung-Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated Circuits – Analysis and Design", TMH, 2011.
2. Kiat-Seng Yeo, Kaushik Roy, "Low-Voltage, Low-Power VLSI Subsystems", TMH Professional Engineering, 2004.

REFERENCES:

1. Ming-BO Lin, "Introduction to VLSI Systems: A Logic, Circuit and System Perspective", CRC Press, 2012.
2. Kaushik Roy, Sharat C. Prasad, "Low Power CMOS VLSI Circuit Design", John Wiley, & Sons, 2000.
3. Siva G. Narendran, Anatha Chandrakasan, "Leakage in Nanometer CMOS Technologies", Springer, 2005.

COURSE OUTCOMES:

Students will be able to:

Course Name: LOW POWER IC DESIGN		Course Code: 24EEV14	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the fundamentals of Low power circuit design.	I	K3
CO2	Describe the knowledge of architectural approaches.	II	K3
CO3	Analyze and design Low-Voltage Low-Power combinational circuits.	III	K3
CO4	Develop the design of Low-Voltage Low-Power Memories.	IV	K3
CO5	Design and develop Low Power, Low Voltage Circuits.	V	K3

24EEV24	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on

- Classification of signals and systems & their mathematical representation.
- Analysis of discrete-time systems using different types of transforms.
- Computation of Discrete Fourier Transform using FFT algorithm.
- Design of IIR and FIR digital filters using impulse invariant and bilinear transformation techniques and using various window functions.
- Architecture of digital signal processor.

UNIT – I INTRODUCTION TO SIGNALS AND SYSTEMS 9

Classification of signals: Continuous and discrete, energy and power; mathematical representation of signals; operation of signals, Classification of systems: Continuous and discrete, linear, causal, stable, dynamic, recursive, time variance; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.

UNIT – II DISCRETE TIME SYSTEM ANALYSIS 9

Z-transform and its properties, ROC - inverse z-transforms-Long division, Partial Fraction Expansion method - difference equation — Solution by Z-transform, Application to discrete systems - Stability analysis, frequency response- Linear Convolution – Analysis of LTI systems in z-domain.

UNIT - III DISCRETE FOURIER TRANSFORM & COMPUTATION 9

DFT - Properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure – Inverse DFT using FFT algorithm, Circular Convolution.

UNIT - IV DESIGN OF DIGITAL FILTERS 9

IIR design: IIR filter Realization: Direct Form I and II, Cascade and Parallel forms - Analog filter design - Butterworth and Chebyshev approximations (LPF and HPF) - Digital filter design using Impulse invariant and Bilinear transformation.

FIR design: FIR filter Realization - Linear Phase Characteristics - Filter design using Windowing Techniques (Rectangular, Hamming, Hanning windows only)

UNIT - V DIGITAL SIGNAL PROCESSORS 9

Introduction – TMS320C5X Architecture DS Processor – Features – Addressing Modes – Functional modes - Introduction to Commercial DS Processors - Application: Musical sound processing system.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John G. Proakis, D.G. Manolakis and D.Sharma, “Digital Signal Processing Principles, Algorithms and Applications”, 4th edition, Pearson Education, 2012.
2. Sanjit K. Mitra, “Digital Signal Processing - A Computer based approach", 4th edition, McGraw-Hill, 2013.

REFERENCES:

1. Alan V Oppenheim, Ronald W Schafer, John R Back, “Discrete Time Signal Processing”, 3rd edition, Pearson new international edition, 2014.
2. Emmanuel C. Ifeachor & Barrie W. Jervis - Digital Signal Processing - A practical Approach, 2nd edition, Prentice Hall, 2011.

OUTCOMES:

STUDENTS WILL BE ABLE TO:

Course Name : DIGITAL SIGNAL PROCESSING		**Course Code: 24EEV24**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Identify the type of given discrete time signals and systems.	I	K3
CO2	Apply Z-transform to analyze the given discrete time systems.	II	K3
CO3	Apply FFT algorithm to compute DFT.	III	K3
CO4	Design FIR filter using windowing techniques (Rectangular, Hamming and Hanning) for the given specifications.	IV	K3
CO5	Explain the architecture of digital signal processors and its addressing modes.	V	K3

24EEV34	EMBEDDED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain Building Blocks of a Embedded System and software Tools.
- To understand role of Input/output interfacing with Bus Communication protocol.
- To understand ISR and scheduling for multi-task process.
- To introduce the basics of a Real time operating system.
- To discuss applications based on embedded design approaches.

UNIT – I INTRODUCTION TO EMBEDDED SYSTEMS 9

Introduction to Embedded Systems – The build process for embedded systems - Structural units for an Embedded microcontroller , selection of processor & memory devices- DMA — Memory management methods - Timer and Counting devices, Watchdog Timer, Real Time Clock - IDE, assembler, compiler, linker, simulator, debugger, In-circuit emulator, Target Hardware Debugging, Boundary Scan.

UNIT – II EMBEDDED NETWORKING 9

Embedded Networking: Introduction, I/O Device Ports & Buses – Serial Bus communication protocols - RS232 standard – RS485 – USB Bus - Serial Peripheral Interface (SPI) – Inter Integrated Circuits (IIC)

UNIT - III INTERRUPTS SERVICE MECHANISM AND DEVICE DRIVERS 9

Programmed I/O busy-wait approach without interrupt service mechanism - ISR concept - interrupt sources – multiple interrupts – context and periods for context switching, interrupt latency and deadline – Introduction to Device Drivers.

UNIT - IV RTOS BASED EMBEDDED SYSTEM 9

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Pre emptive and non-pre emptive scheduling, Task communication shared memory, message passing, Inter process Communication — synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of commercial Real time Operating systems: VxWorks, µC/OS-II, RT Linux.

UNIT - V EMBEDDED SYSTEM APPLICATION WITH DEVELOPMENT 9

Case Study: Washing Machine - Automotive Application - RFID-System, Application, Embedded Product Development Life Cycle, Objective, Need, and different Phases & Modelling of the EDLC.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rajkamal, ‘Embedded System-Architecture, Programming, Design’, Mc Graw Hill, 2013
2. Peckol, ‘Embedded system Design’, John Wiley & Sons, 2010
3. Shibu. K.V, ‘Introduction to Embedded Systems’, Tata Mcgraw Hill, 2009

REFERENCES:

1. Elicia White, ‘Making Embedded Systems’, O’ Reilly Series SPD,2011
2. Tammy Noergaard, ‘Embedded Systems Architecture’, Elsevier, 2006
3. Han-Way Huang, ‘Embedded system Design Using C8051’, Cengage Learning, 2009
4. Rajib Mall, ‘Real-Time systems Theory and Practice’, Pearson Education, 2007

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : EMBEDDED SYSTEM DESIGN		Course Code: 24EEV34	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the basic build process of embedded systems	I	K2
CO2	Classify the different types of I/O device ports, buses and different interfaces for data transfer in embedded networking	II	K3
CO3	Illustrate the interrupt service mechanism and device drivers.	III	K3
CO4	Generalize the basic concept of Real Time Operating Systems	IV	K3
CO5	Apply the knowledge of programming concepts of Embedded Systems for various applications	V	K3

24EEV44	EMBEDDED PROCESSORS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide the students with basic knowledge of Arduino microcontroller and types of signals.
- To Train the students in the basics of different types of basic sensors and their practical usage.
- To train the students on optimal selection of components based on the application.
- To provide the students with hands on experience on handling of microcontrollers and other components to provide them an edge in fast moving industry.

UNIT - I Introduction to Embedded Systems 9

Understanding embedded system - Overview of basic electronics and digital electronics - Microcontroller & microprocessor - Comparison between the two microcontroller (vs) microprocessor - Common features of microcontroller - Different types of microcontroller.
Introduction to Arduino - Pin configuration and architecture - Device and platform features Concept of digital and analog ports - Familiarizing with Arduino Interfacing Board Introduction to Embedded C and Arduino platform

UNIT - II Review of Basic Concepts of Arduino 9

Arduino data types - Variables and constants — Operators - Control Statements — Arrays — Functions - Pins Configured as input - Pull-up Resistors - Pins Configured as output-pin Mode () Function-digital Write () Function - analog Read() function — Arduino Interrupts — Arduino Time - delay () function - millis () function - micros () function

UNIT - III Arduino Displays and Sensors 9

Working with Serial Monitor - Line graph via serial monitor - Interfacing a 8 bit LCD to Arduino Fixed one line static message display - Running message display-Using the LCD Library of Arduino - HC-SR04 Ultrasonic Module - IR Infrared Obstacle Avoidance sensor - Soil Moisture Sensor - Photo resistor sensor - Digital thermal sensor — Temperature sensor - Rotary Encoder Module - MQ-2 Gas sensor - SW-420 Motion sensor - Humidity and Rain Detection sensor - IR Infrared Flame Detection sensor - 5V/12V-Relay module (2 channel to 16 channel) - DHT11 Temperature and Humidity sensor

UNIT - IV Arduino Secondary Integrations 9

Types of Relays -Controlling Electrical appliances with electromagnetic relays -Working of a matrix keypad - Using the keypad library to interface with Arduino - Interfacing Servo motors to Arduino - Interfacing a RF Module - Giving Input to the controller - Using serial input - Controlling LEDs with keys - Keys as toggle switch - Interfacing a piezo buzzer - Using a buzzer as an alarm unit

UNIT - V Arduino Communications, IOT and Cloud Computing 9

Serial /Parallel Communication - Types of Serial Communications - Arduino UART - GSM/GPRS Arduino Interfacing - IOT and Cloud Computing - Understanding IoT fundamentals - IOT Architecture and protocols - Overview of IoT - components and IoT Communication Technologies Basics of Wireless Networking - Introduction to ESP8266 Wi-Fi Module - Various Wi-Fi library Web server - Introduction, installation, configuration - Posting sensor(s) data to web server - Virtualization concepts and Cloud Architecture - Cloud computing, benefits - Cloud services - SaaS, PaaS, IaaS - Cloud providers & offerings -Study of IOT Cloud platforms — Thing Speak API and MQTT - Interfacing ESP8266 with Web services - Making it a reality - Arduino Projects

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Embedded System-Architecture, Programming, Design, Rajkamal, McGraw Hill, 2013
2. Embedded system Design, Peckol, John Wiley & Sons, 2010

REFERENCES:

1. Introduction to Embedded Systems, Shibu. K.V, Tata Mcgraw Hill,2009
2. Real-Time systems Theory and Practice, Rajib Mall, Pearson Education, 2007
3. Embedded system Design Using C8051, Han-Way Huang, Cengage Learning, 2009

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : EMBEDDED PROCESSORS		**Course Code: 24EEV44**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Illustrate the basics of Embedded processors and Arduino development boards	I	K3
CO2	Generalize the programming concepts of Arduino development kits	II	K3
CO3	Elaborate the interfacing of display units in Arduino development boards	III	K3
CO4	Explain the interfacing of relays and motors in Arduino development boards	IV	K3
CO5	Discuss the interfacing of IoT applications in clouds by using Arduino development boards	V	K3

24EEV54	EMBEDDED C-PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to the fundamentals of embedded Programming
- To Introduce the GNU C Programming Tool Chain in Linux.
- To study the basic concepts of embedded C.
- To teach the basics of Python Programming
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts

UNIT - I BASIC C PROGRAMMING **9**

Typical C Program Development Environment - Introduction to C Programming - Structured Program Development in C - Data Types and Operators - C Program Control - C Functions - Introduction to Arrays.

UNIT - II EMBEDDED C **9**

Adding Structure to 'C' Code: Object oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts.

UNIT - III C PROGRAMMING TOOL-CHAIN IN LINUX **9**

C preprocessor - Stages of Compilation - Introduction to GCC - Debugging with GDB - The Make utility - GNU Configure and Build System - GNU Binary utilities - Profiling - using gprof Introduction to GNU C Library.

UNIT - IV PYTHON PROGRAMMING **9**

Introduction - Parts of Python Programming Language - Control Flow Statements - Functions – Strings - Lists - Dictionaries - Tuples and Sets.

UNIT - V MODULES, PACKAGES AND LIBRARIES IN PYTHON **9**

Python Modules and Packages - Creating Modules and Packages - Practical Example - Libraries for Python - Library for Mathematical functionalities and Tools - Numerical Plotting Library - GUI Libraries for Python - Imaging Libraries for Python - Netoworking Libraries.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Michael J Pont, "Embedded C", Addison-Wesley, Anim print of Pearson Education, 2002.
2. Fabrizio Romano, "Learn Python Programming", Second Edition, Packt Publishing, 2018.

REFERENCES:

1. Paul Deitel and Harvey Deitel, "C How to Program", 8th Edition, Pearson Education Limited, 2016.
2. Noel Kalicharan, "Learn to Program with C", Apress Inc., 2015.
3. John Paul Mueller, "Beginning Programming with Python for Dummies", 2nd Edition, John Wiley& Sons Inc., 2018.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : EMBEDDED C-PROGRAMMING		**Course Code: 24EEV54**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Demonstrate C programming and its salient features for embedded systems	I	K3
CO2	Discuss various programming languages/software compatible to embedded process development with improved design & programming skills.	II	K3
CO3	Develop knowledge on C programming in Linux environment.	III	K3
CO4	Illustrate python programming for Embedded applications.	IV	K3
CO5	Develop the Modules, Packages and Libraries for Python.	V	K3

24EEV64	SMART SYSTEM AUTOMATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the smart system technologies and its role in real time applications
- To teach the architecture and requirements of Home Automation
- To provide an insight into smart appliances and energy management concepts
- To familiarize the design and needs of smart wearable devices
- To teach the basics of robotics and its role for automation.

UNIT - I INTRODUCTION 9

Overview of a smart system – Hardware and software selection – Smart sensors and Actuators – Communication protocols used for smart systems

UNIT - II HOME AUTOMATION 9

Home Automation – System Architecture - Essential Components - Design Considerations: Control Unit, Sensing Requirements, Communication, Data Security.

UNIT - III SMART APPLIANCES AND ENERGY MANAGEMENT 9

Significance of smart appliances for energy management Smart Meters: Significance, Architecture & Energy Measurement Technique – Security Considerations.

UNIT - IV SMART WEARABLE DEVICES 9

Body Area Networks – Sensors – communication protocol for Wearable devices – Application of Smart Wearable in Healthcare & Activity Monitoring.

UNIT - V EMBEDDED SYSTEMS AND ROBOTICS 9

Fundamental concepts in Robotics – Robots and Controllers components – Embedded processor based: pick and place robot – Mobile Robot Design - UAV.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Grimm, Christoph, Neumann, Peter, Mahlknechand Stefan, Embedded Systems for Smart Appliances and Energy Management, Springer 2013, 1st Edition
2. Kazem Sohraby, Daniel Minoli and Taieb Znati, Wireless Sensor Networks Technology, Protocols, and Applications, John Wiley & Sons, 2007, 1stEdition
3. Nilanjan Dey, Amartya Mukherjee, Embedded Systems and Robotics with Open-Source Tools, CRCpress, 2016, 1st Edition

REFERENCES:

1. Thomas Bräunl, Embedded Robotics, Springer, 2003
2. Raj Kamal, Embedded Systems - Architecture, Programming and Design, McGraw-Hill, 2008
3. Karim Yaghmour, Embedded Android, O'Reilly, 2013
4. Steven Goodwin, Smart Home Automation with Linux and Raspberry Pi, Apress, 2013

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: SMART SYSTEM AUTOMATION		Course Code: 24EEV64	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Discuss the overview and communication protocols used for smart systems.	I	K3
CO2	Explain the System Architecture, Essential Components and Design Considerations of Home Automation.	II	K3
CO3	Describe the Architecture, Energy Measurement Technique, Security Considerations of Smart Meters.	III	K3
CO4	Summarize the function of Body Area Networks, Sensors, communication protocol and Applications of smart Wearable devices.	IV	K3
CO5	Design the Embedded processor based pick and place robot and Mobile Robot.	V	K3

24EEV74 EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS L T P C
3 0 0 3

OBJECTIVES:

- To expose the students to the fundamentals and building of Electronic Engine Control systems**.**
- To teach on sensor functional components for vehicles.
- To discuss on programmable controllers for vehicles management systems.
- To teach logics of automation & communication techniques for vehicle communication.
- To introduce the infotainment system development.

UNIT - I INTRODUCTION TO AUTOMOTIVE SYSTEMS 9

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Electronic control Unit – open-source ECU

UNIT - II SENSORS AND ACTUATORS FOR AUTOMOTIVES 9

Review of automotive sensors – sensors interface to the ECU, Smart sensor and actuators for automotive applications

UNIT - III VEHICLE MANAGEMENT SYSTEMS 9

Energy Management system – Adaptive cruise control - anti-locking braking system – Safety and Collision Avoidance

UNIT - IV ONBOARD DIAGONSTICS AND COMMUNICATION 9

OBD, Vehicle communication protocols - Bluetooth, CAN, LIN, FLEXRAY and MOST.

UNIT - V RECENT TRENDS 9

Navigation – Autonomous car – Role of IoT in Automotive systems.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. William B. Ribbens, “Understanding Automotive Electronics”, Elseiver, 8th Edition, 2017.
2. Jurgen, R., “Automotive Electronics Hand Book”, McGraw Hill, 2nd Edition, 1999.
3. L.Vlacic, M.Parent, F.Harahima, ”Intelligent Vehicle Technologies”, SAE International, 2001,1st Edition, 2017.

REFERENCES:

1. Jack Erjavec, Jeff Arias, “Alternate Fuel Technology - Electric, Hybrid & Fuel Cell Vehicles”, Cengage, 2012, 2nd Edition.
2. Automotive Electricals / Electronics System and Components, Tom Denton, 5th Edition, 2017.
3. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5th Edition, 2014.
4. Automotive Hand Book, Robert Bosch, Bently Publishers,10th Edition, 2018.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS		**Course Code: 24EEV74**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Outline the overview of Automotive systems	I	K3
CO2	Summarize the operation of Smart sensor and actuators for automotive applications.	II	K3
CO3	Explain the Embedded concepts for vehicle management and control systems.	III	K3
CO4	Discuss the function of onboard diagnostics and Vehicle communication protocols.	IV	K3
CO5	Describe the operation of Autonomous car and Navigation.	V	K3

Vertical – V – Artificial Intelligence and data Science for power System Engineering

20EEV15	BIG DATA ANALYTICS IN POWER SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the fundamentals of a computer system and operations.
- To learn the arithmetic and logic unit and implementation of fixed-point and floating point arithmetic unit.
- To learn the basics of pipelined execution.
- To understand parallelism and multi-core processors
- To understand the memory hierarchies and different ways of communication with I/O devices.

UNIT I BIG DATA IN POWER SYSTEMS **9**

Introduction to big data concepts in power systems — Holistic data management approaches – Challenges in data security and privacy for utilities – Cognitive computing applications – Frameworks and architectures for big data integration in power sector.

Activity: Case Study Presentation on Big Data Integration in Power Utilities.

UNIT II DATA ANALYTICS TECHNIQUES – I **9**

Agile machine learning approaches for power system data — Unsupervised learning techniques for system behavior analysis – Application of deep learning models in power system monitoring and control.

Activity: Clustering of power system load profiles using unsupervised learning techniques and develop a machine

UNIT III DATA ANALYTICS TECHNIQUES – II **9**

Compressive sensing methods for sparse data recovery — Time-series classification techniques – Review of analytics tools and applications using power system datasets – Introduction to R programming for power system analytics.

Activity: Implement compressive sensing techniques for sparse power system data recovery and perform time-series classification using R programming, along with reviewing analytics tools and their applications to real-world power system datasets.

UNIT IV APPLICATIONS OF BIG DATA IN POWER SYSTEMS **9**

Supervised learning methods for fault location – Data-driven techniques for voltage unbalance analysis in distribution networks – Predictive analytics approaches for energy system state estimation

Activity: Simulations using supervised learning models for fault location in power grids, simulate data-driven voltage unbalance analysis in distribution networks, and apply predictive analytics techniques for simulating energy system state estimation.

UNIT V DATA ANALYTICS IN ENERGY MARKETS **9**

Analytical methods for energy disaggregation – Use cases and implementation techniques – Addressing the trade-off between utility-level insights and consumer data privacy in energy data analytics

Activity: Simulations using analytical methods for energy disaggregation, implement selected use cases, and analyze the trade-off between utility-level insights and consumer data privacy in energy data analytics.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Reza Arghandeh, Yuxun Zhou, “Big Data Application in Power Systems”, Elsevier Science, 2017
2. Ali Tajer, Samir M. Perlaza ,H. Vincent Poor “Advanced Data Analytics for Power Systems”, Cambridge University Press, 2021

REFERENCES:

1. Hasmat Malik, Md. Waseem Ahmad, D.P. Kothari, “Intelligent Data Analytics for Power and Energy Systems”, Springer, 2022
2. Ahmed F. Zobaa, Trevor J. Bihl, “Big Data Analytics in Future Power Systems”, CRC Press, 2018

OUTCOMES:

STUDENTS WILL BE ABLE TO:

Course Name: BIG DATA ANALYTICS IN POWER SYSTEMS		**Course Code: 24EEV15**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the fundamentals of big data concepts, data management frameworks, and privacy challenges in power systems.	I	K3
CO2	Apply machine learning and deep learning techniques for effective analysis and decision-making in power system operations.	II	K3
CO3	Analyze time-series data using compressive sensing and classification methods, and utilize R programming for power system analytics.	III	K3
CO4	Simulate supervised learning models and predictive analytics for fault detection, voltage unbalance analysis, and state estimation in power networks.	IV	K3
CO5	Evaluate and implement data analytics techniques for energy disaggregation while addressing utility-consumer privacy trade-offs.	V	K3

24EEV25	GENERATIVE AI FOR POWER GRID	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO GEN AI 9

Historical Overview of Generative Modeling – Difference between Gen AI and Discriminative Modeling – Importance of Generative Models in AI and Machine Learning – Types of Generative Models – GANs, VAEs, Autoregressive Models and Vector Quantized Diffusion Models – Understanding of Probabilistic Modeling and Generative Process – Challenges of Generative Modeling – Future of Gen AI – Ethical Aspects of AI –
Responsible AI – Use Cases.

UNIT II GENERATIVE MODELS FOR TEXT 9

Language Models Basics – Building Blocks of Language Models – Transformer Architecture – Encoder and Decoder – Attention Mechanisms – Generation of Text – Models like BERT and GPT Models – Generation of Text – Autoencoding – Regression Models – Exploring ChatGPT – Prompt Engineering – Designing Prompts– Revising Prompts using Reinforcement Learning from Human Feedback (RLHF) – Retrieval
Augmented Generation – Multimodal LLM – Issues of LLM like hallucination.

UNIT III GENERATION OF IMAGES 9

Introduction to Generative Adversarial Networks – Adversarial Training Process – Nash Equilibrium – Variational Autoencoders – Encoder– Decoder Architectures – Stable Diffusion Models – Introduction to Transformer based Image Generation – CLIP – Visual Transformers ViT– Dall– E2 and Dall– E3, GPT- 4V –
Issues of Image Generation Models like Mode Collapse and Stability.

UNIT IV GENERATION OF PAINTING, MUSIC, AND PLAY 9

Variants of GAN – Types of GAN – Cyclic GAN – Using Cyclic GAN to Generate Paintings – Neural Style
Transfer – Style Transfer – Music Generating RNN – MuseGAN – Autonomous agents – Deep Q Algorithm – Actor-Critic Network.

UNIT V POWER GRID OPERATION AND AI 9

Power Grid operation and AI-Applications-Decision making-Energy forecasting-Power system identification and modeling-AI enhances Grid operation with EGrid GPT-importance of Power Grid models and Data- Validating models and cleansing Datasets-standardization of AI- Human- AI collaboration-Ethical, social and policy considerations

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Denis Rothman, Transformers for Natural Language Processing and Computer Vision – Third Edition, Packt Books, 2024

REFERENCES:

1. Generative Deep Learning, David Foster, O'Reily Books, 2024.
2. Generative AI for Everyone – Altaf Rehmani – Blue Rose One – 2024.
3. Generative AI for Power Grid Operations-Technical report-NREL- Nov 2024.

OUTCOMES:

STUDENTS WILL BE ABLE TO:

Course Name: GENERATIVE AI FOR POWER GRID		Course Code: 24EEV25	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the concepts of Generative Modeling	I	K3
CO2	Apply Gen AI to Generating Texts	II	K3
CO3	Discuss and Apply Gen AI for generating video.	III	K3
CO4	Apply Gen AI for Video, painting, and Music Generation.	IV	K3
CO5	Apply Gen AI for power grid operation.	V	K3

24EEV35	PYTHON PROGRAMMING FOR DATA SCIENCE	L	T	P	C
		3	0	0	3

Objectives:

- To impart knowledge on Python programming and how it can be used for solving problems.
- To illustrate how to handle, clean, and analyze data using Python libraries.
- To make use of Python tools and open datasets for real-world data science applications.

UNIT I Basics of Python, Functions and Files 9

Overview of python, Data Structures and Sequences: List, Tuple, Set, Dictionaries. Defining a Function, Passing Arguments, Return Values, Passing a List, Creating and Using a Class, Strings: Working with Strings, String Methods, Files: Reading from a File, Writing to a File, Exceptions, Python Libraries: Importing libraries.

UNIT II Foundations of Data Science 9

Introduction to Data Science- Applications of Data Science - Data Science Process: Overview, Defining Research Goals, Retrieving Data - Data Preparation: Data Wrangling- Handling Missing Data- Data Transformation, regression, Exploratory Data Analysis, Build the Model, Present Findings, Data Mining, Data Warehousing.

UNIT III Descriptive Analytics 9

Facets of Data, Types of Variables, Statistical Description of Data, Describing Data with Tables and Graphs, Describing Data with Averages, Describing Variability, Normal Distributions and Standard (z) Scores, Correlation, Scatter plots, correlation coefficient for quantitative data –computational formula for correlation coefficient, Regression, Regression line, least squares regression line.

UNIT IV Numpy and Pandas Libraries 9

Creating Arrays, attributes, Numpy Arrays objects, Basic operations (Array Join- split- search- sort), Indexing, Slicing and Iterating, Copying Arrays, Arrays shape Manipulation, Identity Array, eye function. Exploring Data using Series- Exploring Data using Data Frames, Index objects- reindex, Drop Entry, Selecting Entries- Data Alignment, Rank and Sort, Summary Statistics, Index Hierarchy.

UNIT V Data Visualization and Energy System Modelling 9

Introduction to Matplotlib, Plots, making subplots, Controlling axes, Ticks, Labels and legends, Annotations and drawing on subplots, Saving plots to files, Seaborn library, Making sense of data through advanced visualization, Controlling the properties of Chart, Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot, Styling your plot, 3D plot of surface.Data perspective on Power Systems,PMU data for anomaly detection and localization,

TOTAL: 45 PERIODS

References:

1. Grus, J. (2019). Data science from scratch (2nd ed.). O'Reilly Media, Inc.
2. McKinney, W. (2018). Python for data analysis: Data wrangling with pandas, NumPy, and I Python. O'Reilly Media, Inc.
3. Le Xie,Yang Weng,Ram RajaGopal(2023),Data Science and Applications for Power Systems,Springer. 4.Thereja, R. (2022). Data science and machine learning using Python (1st ed.). Tata McGraw Hill.

OUTCOMES:

STUDENTS WILL BE ABLE TO:

Course Name: PYTHON PROGRAMMING FOR DATA SCIENCE		Course Code: 24EEV35	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply Python functions, file handling, and object-oriented programming to solve structured problems.	I	K3
CO2	Explain Data Science, Process	II	K3
CO3	Discuss data descriptive analytics	III	K3
CO4	Design and analyze data-driven solutions using NumPy, Pandas and Matplotlib.	IV	K3
CO5	Develop continuous learning skills to use open-source tools and public datasets for data science tasks.	V	K3

24EEV45	DATA ANALYTICS FOR POWER SYSTEM SECURITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic concepts of Data Analytic.
- To Handle missing data in the real world datasets by choosing appropriate methods
- To Learn data analysis methods
- To learn stream computing
- To Understand and apply Data Analysis Techniques.

UNIT I INTRODUCTION **9**

Knowledge domains of Data Analysis, understanding structured and unstructured data, data analytic tools, applications of data analytics, various phases of data analytics lifecycle–discovery, data preparation, model planning, model building, communicating results, operationalization.

UNIT II DATA PREPROCESSING **9**

Data Preprocessing: Data Cleaning–Data Integration-Data Reduction– Data Transformation Handling Missing Data: Introduction to Missing data, Traditional methods for dealing with missing data, Maximum Likelihood Estimation – Basics, Missing data handling, improving the accuracy of analysis.

UNIT III CLASSIFICATION AND CLUSTERING **9**

Statistical Methods: Regression modelling, Multivariate Analysis- Classification: SVM & Kernel Methods- Rule Mining-Cluster Analysis, Types of Data in Cluster Analysis, Partitioning Methods, Hierarchical Methods, Density Based Methods, Grid Based Methods, Model Based Clustering Methods, Clustering High Dimensional Data-
Predictive Analytics.

UNIT IV MINING DATA STREAMS **9**

Streams: Concepts – Stream Data Model and Architecture - Sampling data in a stream -Mining Data Streams and Mining Time-series data- Real Time Analytics Platform (RTAP)Applications. Case Study: Text,Web and Social Media Analytics, Real Time Sentiment

UNIT V HADOOP FRAMEWORKS AND POWER SYSTEM APPLICATIONS **9**

HADOOP– HDFS concepts, Algorithms using Map Reduce, Introduction to NoSQL, Analysis, Stock Market Predictions. Data Analytics pertaining to Power system Security : Concept of Big data Analytics in Electrical utilities,Sources of Data generation in Big data analytics, Application of Machine Learning Algorithms For Power System Security- Support Vector Machine, Feature Selection Process.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John Wiley & Sons, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services (Editor),2015
2. Ali Tajer (Editor), Samir M. Perlaza (Editor), H. Vincent Poor (Editor), Advanced Data Analytics for Power Systems , Cambridge University Press, April 2021.

REFERENCES*:*

1. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Wiley, 2012
2. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.

OUTCOMES:
STUDENTS WILL BE ABLE TO:

Course Name: Data Analytics for Power System Security		**Course Code: 24EEV45**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Explain the basic concepts of Data Analytics	I	K3
CO2	Describe the Data Analysis preprocessing Techniques.	II	K3
CO3	Apply the Classification and Clustering algorithms for real time applications	III	K3
CO4	Apply intelligent analytics techniques like neural networks, fuzzy and genetic algorithms for real time analytics applications	IV	K3
CO5	Explain the power system applications of data analytics	V	K3

24EEV55	CLOUD COMPUTING FOR POWER SYSTEM APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the principles of cloud architecture, models and infrastructure.
- To understand the concepts of virtualization and virtual machines.
- To gain knowledge about virtualization Infrastructure.
- To explore and experiment with various Cloud deployment environments.
- To learn about the security issues in the cloud environment.

UNIT I CLOUD ARCHITECTURE MODELS AND INFRASTRUCTURE 9

Cloud Architecture: System Models for Distributed and Cloud Computing – NIST Cloud Computing Reference Architecture – Cloud deployment models – Cloud service models; Cloud Infrastructure: Architectural Design of Compute and Storage Clouds – Design Challenges

UNIT II VIRTUALIZATION BASICS 9

Virtual Machine Basics – Taxonomy of Virtual Machines – Hypervisor – Key Concepts – Virtualization structure – Implementation levels of virtualization – Virtualization Types: Full Virtualization – Para Virtualization – Hardware Virtualization – Virtualization of CPU, Memory and I/O devices.

UNIT III VIRTUALIZATION INFRASTRUCTURE AND DOCKER 9

Desktop Virtualization — Network Virtualization — Storage Virtualization — System-level of Operating Virtualization — Application Virtualization — Virtual clusters and Resource Management – Containers vs. Virtual Machines – Introduction to Docker – Docker Components – Docker Container – Docker Images and Repositories.

UNIT IV CLOUD DEPLOYMENT ENVIRONMENT 9

Google App Engine – Amazon AWS – Microsoft Azure; Cloud Software Environments – Eucalyptus – OpenStack

UNIT V CLOUD DATA METERING DEVICES AND SECURITY CHALLENGES 9

Data Security and Storage; Identity and Access Management (IAM) – IAM Challenges – IAM Architecture and Practices - Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication - Cloud computing in smart grid - Private, public and Hybrid cloud. Cloud architecture of smart grid

TOTAL: 45 PERIODS

Text Books:

1. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, “Distributed and Cloud Computing, From Parallel Processing to the Internet of Things”, Morgan Kaufmann Publishers, 2012.
2. James Turnbull, “The Docker Book”, Turnbull Press, 2014.
3. Krutz, R. L., Vines, R. D, “Cloud security. A Comprehensive Guide to Secure Cloud Computing”, Wiley Publishing, 2010.

REFERENCES:

1. James E. Smith, Ravi Nair, “Virtual Machines: Versatile Platforms for Systems and Processes”, Elsevier/Morgan Kaufmann, 2005.
2. Tim Mather, Subra Kumaraswamy, and Shahed Latif, “Cloud Security and Privacy: an enterprise perspective on risks and compliance”, O’Reilly Media, Inc., 2009.

COURSE OUTCOMES:
STUDENTS WILL BE ABLE TO:

Course Name : Cloud Computing for Power System Applications		Course Code: 24EEV55	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Describe the cloud architecture, cloud deployment & service models and challenges of cloud design	I	K3
CO2	Apply the concept of virtualization and its types	II	K3
CO3	Explain the various types of virtualization infrastructure	III	K3
CO4	Develop and deploy services on the cloud and set up a cloud environment	IV	K3
CO5	Explain security challenges in the cloud environment	V	K3

24EEV65	MACHINE LEARNING TECHNOLOGY FOR POWER SYSTEM APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basics of Machine Learning (ML)
- To understand the concepts of Supervised Learning
- To understand the concepts of Unsupervised Learning
- To understand the concepts of Reinforced Learning
- To design and analysis of Machine Learning Experiments

UNIT I MACHINE LEARNING BASICS **9**

Introduction to Machine Learning (ML) - Essential concepts of ML — Types of learning — MachinelearningmethodsbasedonTime–Dimensionality–LinearityandNonlinearity Early trends in Machine learning–Data Understanding Representation and visualization – Confusion Matrix - MSE

UNIT II SUPERVISED LEARNING **9**

Regression: Types – Linear Regression, Ridge Regression, Polynomial Regression, Bayesian linear regression, Classification – binary classification, Gradient Descent – Choosing Step size, Support Vector Machine, Decision Tree, Random Forest K Nearest Neighbours, Naïve Bayes.

UNIT III UNSUPERVISED LEARNING **9**

Unsupervised learning: K-means clustering, Hierarchal clustering, Anomaly detection, Principle Component Analysis, Independent Component Analysis, Singular value decomposition.

UNIT IV REINFORCED LEARNING **9**

Introduction to Reinforced Learning terminology, component, working of Reinforcement Learning Reinforcement Learning Algorithm – Approaches, types – positive type, negative type. Learning Models – Introduction to Markov decision process (MDP), state and action value functions – Application of Reinforcement Learning

UNIT V MACHINE LERNING TECHNIQUES FOR POWER SYSTEM **9**

Cross Validation (CV) and resampling — K-fold CV, bootstrapping, measuring classifier performance, assessing a single classification algorithm and comparing two classification algorithms – *t* test, McNemar's test, K-fold CV paired *t* test. ML algorithms for Power System analysis-Monitoring and Control of Electrical Power Systems using Machine Learning Techniques

TOTAL:45 PERIODS

TEXTBOOKS:

1. Ameet V Joshi, Machine Learning and Artificial Intelligence, Springer Publications, 2020
2. EthemAlpaydin, "Introduction to Machine Learning", MIT Press, Fourth Edition, 2020.
3. Stephen Marsland, "Machine Learning: An Algorithmic Perspective, "Second Edition", CRCPress, 2014.

REFERENCES:

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition, 1997.
3. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", Second Edition, MIT Press, 2012, 2018.
4. Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", MIT Press, 2016
5. SebastainRaschka, VahidMirjalili , "Python Machine Learning", Packt publishing, 3rd Edition, 2019.

OUTCOMES:

On Completion of the course, the students should be able to:

Course Name: MACHINE LEARNING TECHNOLOGY FOR POWER SYSTEM APPLICATIONS		**Course Code:24EEV65**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Explain the basic concept of Machine Learning and its performance matrix	I	K3
CO2	Apply the different regression algorithms to predict the value of dependent variable based on an independent variable.	II	K3
CO3	Apply the unsupervised algorithm namely k means to cluster the dataset and principle component analysis to simplify the high dimensional data set.	III	K3
CO4	Explain the concepts of reinforced learning algorithm and its application.	IV	K3
CO5	Explain the various statistical testing methods in Machine Learning for power system experiments.	V	K3

24EEV75	ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND AUTOMATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn concepts of robot locomotion.
- To understand the kinematics models of Robots.
- To learn the sensors used in mobile robots
- To learn the strategies for extracting information from the sensors.

UNIT I ROBOT LOCOMOTION 9

Introduction to AI and Robotics – Legged Mobile Robots- Leg configurations and stability- Examples of legged robot locomotion-Wheeled Mobile Robots-Wheeled locomotion: the design space.

UNIT II MOBILE ROBOT KINEMATICS 9

Kinematic models and constraints — mobile robot maneuverability—mobile robot workspace – Beyond Basic Kinematics– motion control-Open loop control.

UNIT III ROBOT PERCEPTION 9

Sensors for mobile robots — representing uncertainty: statistical representation — error propagation – Feature extraction: Feature extraction based on range data-Visual appearance based feature extraction.

UNIT IV MOBILE ROBOT LOCALIZATION 9

Introduction to localization-The Challenge of Localization: Noise and Aliasing: noise and aliasing – localization-based navigation – belief representation– map representation – probabilistic map-based localization – Localization Systems-autonomous map building.

UNIT V ROBOT PLANNING AND NAVIGATION 9

Planning and reacting: Path planning- obstacle avoidance — navigation architectures: Modularity for code reuse and sharing-Control localization-Techniques for decomposition.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R. Siegwart, I. R. Nourbaksh, and D. Scarramuzza, “Introduction to Autonomous Mobile Robots”, Second Edition, MIT Press, 2011.

REFERENCES

1. Stuart Russel and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Fourth Edition, Pearson Education, 2020.
2. Bhaumik and Arkapravo “From AI to Robotics: Mobile, Social, and Sentient Robots” by CRC Press Taylor & Francis 2017.

OUTCOMES:

STUDENTS WILL BE ABLE TO:

Course Name: ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND AUTOMATION		**CourseCode:24EEV75**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Discuss the concepts of robot locomotion.	I	K3
CO2	Demonstrate the kinematics models of Robots.		K3
CO3	Demonstrate strategies for extracting information from the sensors.	III	K3
CO4	Construct the localization algorithms to locate a robot with respect to its environment.		K3
CO5	Discuss the path planning methods for navigation	V	K3

Vertical – Minor - Electric Vehicles

24EEM01	Electrical Machines	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the Constructional details, the principle of operation, types, performance characteristics and applications of DC generators.
- To explain the need of starters, types and its operation for DC motors and to explain the various methods of testing of DC machines.
- To understand the Constructional details, the principle of operation, types, performance characteristics and applications of Single Phase Transformer.
- To explain the various methods of testing of single phase transformer and types of three phase transformer connections.

UNIT - I DC GENERATOR 9

Constructional Details – Working Principle – Types of Armature Winding and Connections – EMF Equation – Methods of Excitation – Characteristics of Series, Shunt and Compound Generators –Losses, Efficiency and Power Stages in DC Generator – Applications - Testing of DC generator.

UNIT - II DC MOTOR 9

Principle of Operation – Back EMF – Maximum output power - Torque Equation – Types of DC Motor – Characteristics of Series, Shunt and Compound Motor – Losses, Efficiency and Power Stages in DC Motor – Condition for Maximum Efficiency – Applications – Testing of DC motors.

UNIT - III SPEED CONTROL OF DC MACHINES 9

Speed Control Methods – Electric braking – Plugging, dynamic and regenerative braking.

UNIT - IV PERMANENT MAGNET BRUSHLESS DC MOTOR 9

Permanent Magnet materials - Characteristics - construction and principle of operation - Types - Difference between mechanical and electronic commutators - EMF and torque equations - torque speed characteristics – Hall sensors - optical position sensors - Microprocessor Based controller.

UNIT - V PERMANENT MAGNET SYNCHRONOUS MOTOR 9

Principle of operation - EMF and Torque equations - self-control - vector control - Torque speed Characteristics - Microprocessor based control – Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nagrath.I. J and Kothari. D. P., 'Electric Machines', 5th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2017.
2. P.C Sen, 'Principles of Electric Machines and Power Electronics' John Wiley & Sons;3rd edition 2013.

REFERENCES:

1. Bimbra P.S. - Electrical Machinery, 1st Edition, Khanna Book Publishing co(P) Ltd, New Delhi, 2021.
2. S.K. Bhattacharya, 'Electric Machines' McGraw - Hill education, New Delhi, 3rd edition, 2009.
3. Sahdev. S.K., 'Electrical Machines', Cambridge University Press, 2018.

OUTCOMES:
STUDENTS WILL BE ABLE TO:

Course Name: ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND AUTOMATION		**CourseCode:24EEV75**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Explain the construction details and working of D.C generator.	I	K3
CO2	Explain the construction details and working of D.C motor.	II	K3
CO3	Discuss the various methods of speed control of D.C motor.	III	K3
CO4	Describe the constructional details and working of permanent magnet brushless D.C motor.	IV	K3
CO5	Explain the constructional details and working of permanent magnet synchronous motor.	V	K3

24EEM02	POWER CONVERTERS FOR ELECTRIC VEHICLE	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of Power electronic devices
- To study the operation, switching techniques and basics topologies of DC-DC Converter.
- To understand the operation of Controlled rectifiers and Inverters that can be used in electric vehicles
- To understand the operation of Power electronic based drives that can be used in electric vehicles
- To understand the control of hybrid and fuel cell vehicles

UNIT I BASIC POWER ELECTRONIC DEVICES **9**

Diodes – Thyristors - Bipolar Junction Transistors – Metal Oxide Semiconductor Field Effect Transistors - Insulated Gate Bipolar Transistors - Ultra capacitors.

UNIT II DC/DC CONVERTER **9**

Basic Principle of DC–DC Converter - Step-Down (Buck) Converter - Step-Up (Boost) Converter - Buck–Boost Converter - DC–DC Converters Applied in Hybrid Vehicle Systems.

UNIT III RECTIFIERS AND INVERTERS **9**

Single-phase Diode Rectifiers - Filtering Systems in Rectifier Circuits - High-frequency Diode Rectifier Circuits - Single-phase Voltage Source Inverters - Current Source Inverters - Closed- loop Operation of Inverters - Regeneration in Inverters.

UNIT IV ELECTRIC MOTOR DRIVES **9**

DC motor speed control and braking - Chopper control based ac motor drives - four quadrant operation of electric drives.

UNIT V CONTROL OF HYBRID AND FUEL CELL VEHICLES **9**

Fuel Cell Vehicles - Power Electronics Requirements - Propulsion Motor Control Strategies - APU Control System in Series Hybrid Vehicles - Fuel Cell for APU Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, Third Edition, 2019
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, Taylor & Francis Group, Third Edition 2021.

REFERENCES:

1. “Power Electronics”, P.S.Bimbhra, Khanna publications, 2020.
2. “Thyristorised Power Controllers”, G.K.Dubey, New Age international publishers, 2019.
3. “Power Electronic Converters Modeling and Control: with Case Studies”, Seddik basha, Springer, 2018.

OUTCOMES:
STUDENTS WILL BE ABLE TO:

Course Name: Power Converters for Electric Vehicle		**Course Code: 24EEM02**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Explain the basics of various power electronics devices suitable for electric vehicles.	I	K3
CO2	Explain the operation of DC-DC Converters used in electric vehicles	II	K3
CO3	Explain the operation of rectifiers and inverters used in electric vehicles	III	K3
CO4	Explain the various DC and AC motor drives suitable for EV	IV	K3
CO5	Explain the Electric Propulsion unit of Electric vehicles	V	K3

24EEM03	POWER MANAGEMENT FOR ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To compare the concept of EV with hybrid and conventional Electric vehicles
- To understand the need of power electronics converters control in DC and AC drives.
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles
- To discuss alternative energy storage systems.

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS **9**

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS **9**

Architecture of EV's and HEV's – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT III CONTROL OF DC AND AC DRIVES **9**

DC/DC chopper based four quadrant operations of DC drives — Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based
vector control operation – Switched reluctance motor (SRM) drives.

UNIT IV BATTERY ENERGYSTORAGE SYSTEM **9**

Battery Basics, Different types, Battery Parameters, Mathematical modeling of lead acid Batteries, Traction Batteries.

UNIT V ALTERNATIVE ENERGYSTORAGE SYSTEMS **9**

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals" CRC Press, Taylor & Francis Group, Second Edition, 2016.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, Third Edition, 2019.

REFERENCES:

1. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010
2. Simona Onori, Lorenzo Serrao, "Hybrid Electric Vehicles Energy Management Strategies", Springer, 2015
3. Xiong, Rui, "Battery Management Algorithm for Electric Vehicles", Springer, 2020.

OUTCOMES:
STUDENTS WILL BE ABLE TO:

Course Name: POWER MANAGEMENT FOR ELECTRIC VEHICLES		**Course Code: 24EEM03**	
CO	**Course Outcomes**	**Unit**	**K-CO**
CO1	Describe the operation of Electric vehicles and various energy storage technologies for electrical vehicles	I	K2
CO2	Explain the Architecture of EV's and Power Train Components	II	K2
CO3	Classify the Control of DC and AC drives	III	K3
CO4	Illustrate various types of Battery energy storage system	IV	K3
CO5	Generalize the Alternative energy storage system	V	K3

24EEM04	DESIGN, MECHANICS AND CONTROL OF ELECTRIC VEHICLE	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basics of EV and vehicle mechanics
- To know the EV architecture
- To study the energy storage system concepts
- To derive model for batteries and to know the different types of batteries and its charging methods
- To learn the control preliminaries for DC-DC converters.

UNIT I INTERNAL COMBUSTION ENGINES 9

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions

UNIT II ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings - Comparisons of EV with internal combustion Engine vehicles — Fundamentals of vehicle mechanics.

UNIT III TYPES OF BATTERY 9

Batteries in Electric and Hybrid Vehicles - Battery Basics - Battery Parameters. Types - Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (NiMH) Battery- Li-Ion Battery Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal Chloride,

UNIT IV BATTERY MODELING AND CHARGING 9

Research and Development for Advanced Batteries. Battery Modelling, Electric Circuit Models. Battery Pack Management, Battery Charging.

UNIT V CONTROL DESIGN PRELIMINARIES 9

Control Design Preliminaries - Introduction - Transfer Functions – Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter – Gain margin and Phase margin study - open loop mode.

TOTAL: 45 PERIODS

Text Books:

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Power Electronic Converters, : Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley-VCH.

REFERENCES:

1. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall, 1997, 1st Edition.
2. Electrical Machine Fundamentals with Numerical Simulation using MATLAB / SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : DESIGN, MECHANICS AND CONTROL OF ELECTRIC VEHICLE		**Course Code : 24EEM04**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe the concepts related with EV, HEV and to compare the same with internal combustion engine vehicles.	I	K2
CO2	Discuss the fundamentals of vehicle mechanics	II	K3
CO3	Generalize the concepts related with batteries and parameters of battery	III	K3
CO4	Illustrate the modeling of batteries and different types of battery charging	IV	K3
CO5	Classify the control system design preliminaries.	V	K3

24EEM05 ELECTRIC VEHICLE CHARGING SYSTEM

L	T	P	C
3	0	0	3

OBJECTIVE:

- To understand the different types of energy storage system.
- To study about the battery characteristic & parameters
- To model the types of batteries
- To know the concepts of battery management system and design the battery pack.
- To study about the battery testing, disposal and recycling

UNIT - I ENERGY STORAGE SYSTEM 9

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System **Suggested reading**: Study of different types of batteries

UNIT - II BATTERY CHARACTERISTICS & PARAMETERS 9

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

UNIT - III BATTERY MODELLING 9

Approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable Ni Cd battery, Parameterization of the Ni Cd battery model, Simulation examples.

UNIT - IV BATTERY PACK AND BATTERY MANAGEMENT SYSTEM 9

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

UNIT - V BATTERY TESTING, DISPOSAL & RECYCLING 9

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric Hybrid Electric and Fuel Cell Vehicles”, Taylor& Francis Group, 2010.
2. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.

REFERENCES:

1. Guangjin Zhao, “Reuse and Recycling of Lithium-Ion Power Batteries”, John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
2. Arno Kwade, Jan Diekmann, “Recycling of Lithium-Ion Batteries: The LithoRec Way”, Springer, 2018. (ISBN: 978-3-319-70571-2)

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ELECTRIC VEHICLE CHARGING SYSTEM		**Course Code : 24EEM05**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Discuss about the different types of energy storage system.	I	K2
CO2	Describe about the battery characteristic & parameters.	II	K2
CO3	Classify the different types of batteries.	III	K3
CO4	Illustrate the concepts of battery pack design.	IV	K3
CO5	Generalize the battery testing, disposal and recycling.	V	K3

24EEM06	ELECTRIC VEHICLES GRID INTEGRATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the basic details of V2G
- To study the benefits & challenges of V2G
- To learn EV & V2G on the smart grids renewable energy systems
- To know the grid integration

UNIT - I DEFINITION, And STATUS of V2G **9**

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice, V2G - Power Markets and Applications. Electricity Markets and V2G Suitability, Long-Term Storage, Renewable Energy, and Other Grid Applications, Beyond the Grid: Other Concepts Related to V2G.

UNIT - II BENEFITS AND CHALLENGES OF V2G **9**

Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.

UNIT - III CHALLENGES TO V2G **9**

Technical Challenges - Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. The Economic and Business Challenges to V2G - Evaluating V2G Costs and Revenues, EV Costs and Benefits, Adding V2G Costs and Benefits Additional V2G Costs, The Evolving Nature of V2G Costs and Benefits. Regulatory and Political Challenges to V2G, V2G and Regulatory Frameworks, Market Design Challenges, Other V2G Regulatory and Legal Challenges.

UNIT - IV IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS **9**

Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

UNIT - V GRID INTEGRATION AND MANAGEMENT OF EVS **9**

Introduction - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer,2015, 1st Edition.

REFERENCES:

1. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor; Jesus Fraile- Ardanuy, IET 2020, 1st Edition.
2. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
3. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle- to-Grid A Socio-technical Transition Beyond Electric Mobility, 2019, 1st Edition.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: ELECTRIC VEHICLES GRID INTEGRATION		Course Code:24EEM06	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the concepts related with V2G	I	K2
CO2	Discuss the grid connection of 3 phase Q inverter	II	K2
CO3	Generalize the technical, economics. business, regulatory & political challenges related with V2G	III	K3
CO4	Demonstrate the impact of EV and V2G on smart grid system	IV	K3
CO5	Illustrate the concept of grid integration and management of EVs	V	K3

24OE201	ELECTRICAL ENERGY AUDITING AND MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES: To impart knowledge on the following Topics

- Awareness about importance of energy management and auditing.
- Understanding the Energy management on various electrical motors.
- Understanding the Energy management on electric lighting systems.
- Apply the different types of metering methods of energy management and auditing
- Provide the economic models for energy and load management.

UNIT - I INTRODUCTION **9**

Basics of Energy – Need for energy management – Energy accounting – Energy monitoring, targeting and reporting – Energy audit process.

UNIT - II ENERGY MANAGEMENT FOR MOTORS AND COGENERATION **9**

Energy management for electric motors – Transformer and reactors – Capacitors and synchronous machines, energy management by cogeneration — Forms of cogeneration.

UNIT - III LIGHTING SYSTEMS **9**

Energy management in lighting systems – Task and the working space – Light sources – Ballasts – Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics, lighting and energy standards.

UNIT - IV METERING FOR ENERGY MANAGEMENT **9**

Metering for energy management — Units of measure — Utility meters — Demand meters — Instrument transformer burdens – Multi tasking solid state meters, metering location vs requirements, metering techniques and practical examples

UNIT - V ECONOMIC ANALYSIS AND MODELS **9**

Economic analysis – Economic models – Time value of money – Utility rate structures – Cost of electricity – Loss evaluation, load management – Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
2. Eastop T. D & Croft D. R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.

REFERENCES:

1. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
3. Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.
4. Electricity in buildings good practice guide, McGraw-Hill Education, 2016.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : ELECTRICAL ENERGY AUDITING AND MANAGEMENT		**Course Code : 24OE201**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the importance of energy management and auditing.	I	K2
CO2	Describe energy management on different types of electrical equipment.	II	K3
CO3	Discuss the energy management on different types of lighting system and light sources.	III	K3
CO4	Describe the different types of metering methods of energy management and auditing.	IV	K4
CO5	Explain the economic models for energy and load management.	V	K2

24OE202 RENEWABLE ENERGY SOURCES AND TECHNOLOGIES

L	T	P	C
3	0	0	3

OBJECTIVES: To impart knowledge on the following Topics

- Awareness about renewable Energy Sources and technologies.
- Adequate inputs on a variety of issues in harnessing renewable Energy.
- Recognize current and possible future role of renewable energy sources.
- Provide adequate inputs on Hybrid Renewable Energy Systems
- Provide adequate inputs on Intelligent Controllers for Hybrid Systems.

UNIT - I RENEWABLE ENERGY (RE) SOURCES **9**

Environmental consequences of fossil fuel use, Importance of renewable sources of energy,Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

UNIT - II SOLAR AND PV SYSTEMS **9**

Solar Radiation, Radiation Measurement, Central Receiver Power Plants, Solar Ponds.- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems - Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array, PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.

UNIT - III WIND ENERGY **9**

Power in the Wind -Basic principles of Wind Energy Conversion Systems (WECS), Types and Classification of WECS, Parts of WECS, Power, torque and speed characteristics, Stand aloneand grid connected of WECS, Grid integration issues of WECS, Site selection criteria.

UNIT - IV BIOMASS AND HYDRO ENERGY SOURCES **9**

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration- Biomass Gasification, Biomass to Ethanol Production, Biogas production from waste biomass, Environmental Benefits. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT - V GEOTHERMAL , OCEAN AND OTHER ENERGY SOURCES **9**

Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC). Hydrogen Production and Storage- Fuel cell: Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems.

TOTAL: 45PERIODS

TEXT BOOKS:

1. Joshua Earnest, Tore Wizeliu, 'Wind Power Plants and Project Development', PHI Learning Pvt. Ltd, New Delhi, 2011
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt. Ltd, New Delhi, 2013
3. Rai G.D. , Non-Conventional Energy Sources, Khanna Publishers, 2011

REFERENCES:

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011.
2. Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.
3. Shobh Nath Singh, 'Non-conventional Energy resources' Pearson Education, 2015

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: RENEWABLE ENERGY SOURCES AND TECHNOLOGIES		**Course Code : 24OE202**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe about renewable Energy Sources and technologies. Outlinethe Environmental consequences of fossil fuel use	I	K2
CO2	Discuss the basic principle and types of solar PV system and thermal energy systems	II	K2
CO3	Illustrate the basic principles, types and Grid integration issues of Wind Energy Conversion Systems	III	K3
CO4	Generalize the electrical power from bio-mass energy and Hydro energy	IV	K3
CO5	Classify the electrical power from geothermal energy, Ocean energy, Hydrogen energy and Fuel cell.	V	K3

24OE203	ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the Constructional details, the principle of operation, types, performance characteristics and applications of DC motors.
- To understand the various methods of speed control of DC Motors.
- To explain the constructional details and the principle of operation of permanent magnet brushless DC motors.
- To understand the operation of rectifier and invertor.
- To understand the different types of batteries and their characteristics.

UNIT - I DC MOTOR 9

Principle of Operation – Back EMF – Maximum output power - Torque Equation – Types of DC Motor – Characteristics of Series, Shunt and Compound Motor – Losses, Efficiency and Power Stages in DC Motor – Condition for Maximum Efficiency – Applications.

UNIT - II SPEED CONTROL OF DC MOTOR 9

Speed Control Methods – Electric braking – Plugging, dynamic and regenerative braking – Testing of DC motors.

UNIT – III PERMANENT MAGNET BRUSHLESS DC MOTOR 9

Permanent Magnet materials - Characteristics - construction and principle of operation - Types - Difference between mechanical and electronic commutators - EMF and torque equations - torque speed characteristics - Hall sensors - optical position sensors - Microprocessor Based controller.

UNIT - IV POWER CONVERTERS FOR ELECTRIC VEHICLES 9

Single-phase Diode Rectifiers - Filtering Systems in Rectifier Circuits - High-frequency Diode Rectifier Circuits - Single-phase Voltage Source Inverters - Current Source Inverters - Closed-loop Operation of Inverters - Regeneration in Inverters.

UNIT - V ELECTRIC VEHICLE CHARGING SYSTEM 9

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries - Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System **Suggested reading**: Study of different types of batteries.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nagrath.I. J and Kothari. D. P., 'Electric Machines', 5th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2017.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, Taylor & Francis Group, Third Edition 2021.

REFERENCES:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, Third Edition, 2019.
2. Arno Kwade, Jan Diekmann, “Recycling of Lithium-Ion Batteries: The LithoRec Way”, Springer, 2018. (ISBN: 978-3-319-70571-2).

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: Electric Vehicles		**Course Code : 24OE203**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the construction details and working of D.C motor.	I	K2
CO2	Discuss the various methods of speed control of D.C motor.	II	K2
CO3	Illustrate the constructional details and working of permanent magnet brushless D.C motor	III	K3
CO4	Generalize the operation of rectifier and invertor.	IV	K3
CO5	Classify the constructional details and Characteristics of Batteries.	V	K3

24OE204	BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Introduce Fundamentals of Biomedical Engineering
- To understand the measurement of non-electrical parameters and diagnostic procedure.
- To study measurement of certain important electrical parameters and analysis.
- To understand the basic principles in imaging techniques.
- To understand the basic knowledge in life assisting and therapeutic devices.

UNIT I FUNDAMENTALS OF BIOMEDICAL ENGINEERING 9

Cell and its structure – Resting and Action Potential – Propagation of potential -Nervous system and its fundamentals - Cardiovascular systems- Respiratory systems –Kidney and blood flow - Basic components of a biomedical system- Physiological signals and transducers – selection criteria – Applications of Piezoelectric and ultrasonic transducers

UNIT II NON ELECTRICAL PARAMETERS MEASUREMENT AND DIAGNOSTIC PROCEDURES 9

Measurement of blood pressure - Cardiac output - Heart rate - Heart sound - Pulmonary function measurements – spirometer – Photo Plethysmography, Body Plethysmography – Blood Gas analysers, pH of blood –measurement of blood pCO2, pO2, finger-tip oxymeter - ESR, GSR measurements.

UNIT III ELECTRICAL PARAMETERS ACQUISITION AND ANALYSIS 9

Electrodes – Limb electrodes –floating electrodes – pregelled disposable electrodes - Micro, needle and surface electrodes – Amplifiers, Preamplifiers, differential amplifiers, chopper amplifiers – Isolation amplifier - ECG – EEG – EMG – ERG – Lead systems and recording methods – Typical waveforms – Electrical safety in medical environment, shock hazards – leakage current-Instruments for checking safety parameters of biomedical equipment.

UNIT IV IMAGING MODALITIES AND ANALYSIS 9

Radio graphic and fluoroscopic techniques – Computer tomography – MRI – Ultrasonography – Endoscopy – Thermography –Different types of biotelemetry systems - Retinal Imaging – Imaging application in Biometric systems.

UNIT V LIFE ASSISTING, THERAPEUTIC AND ROBOTIC DEVICES 9

Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Heart – Lung machine – Audio meters – Dialysers – Lithotripsy – Laser therapeutic for eye - Robotic surgery – Tele medicine

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Leslie Cromwell, “Biomedical Instrumentation and Measurement”, Prentice Hall of India, 2018.
2. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw-Hill, 2nd edition, 2014

REFERENCES:

1. John G. Webster, Medical Instrumentation Application and Design, John Wiley and sons, 5th Edition, 2020.
2. R.Anandanatarajan, Biomedical Instrumentation and Measurements, PHI Learning Private Limited, 2011.
3. Ed. Joseph D. Bronzino, The Biomedical Engineering Hand Book, 4th dition, Boca Raton, CRC Press LLC, 2015.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name: BIOMEDICAL INSTRUMENTATION		**Course Code : 24OE204**	
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the philosophy of the heart, lung, blood circulation and respiration system.	I	K2
CO2	Describe the concept of measurement of non-electrical parameters.	II	K2
CO3	Classify the various sensing and measurement devices of electrical origin	III	K3
CO4	Generalize the construction and working of imaging device and their analysis	IV	K3
CO5	Illustrate the working of medical assistance/techniques, robotic and therapeutic equipment's	V	K3