GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)

Coimbatore - 641 013

Curriculum For

B.E DEGREE PROGRAM

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

FOR WORKING PROFESSIONALS

2025

Regulations

OFFICE OF CONTROLLER OF EXAMINATIONS
GOVERNMENT COLLEGE OF TECHNOLOGY
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GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

FOR WORKING PROFESSIONALS

2025 REGULATIONS

(Candidates admitted during 2025-2026 and onwards)

First Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE1Z1	Applied Mathematics - I	40	60	100	3	0	0	3
2	25WPE1Z2	Environmental Science and Engineering	40	60	100	3	0	0	3
3	25WPE103	Programming in C	40	60	100	3	0	0	3
4	25WPE104	Electric Circuit Theory	40	60	100	3	0	0	3
PRACTICAL									
5	25WPE105	Programming in C Laboratory	60	40	100	0	0	3	1.5
TOTAL					500	12	0	3	13.5

Second Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE2Z1	Applied Mathematics - II	40	60	100	3	0	0	3
2	25WPE202	Electronic Devices and Circuits	40	60	100	3	0	0	3
3	25WPE203	Digital Circuits	40	60	100	3	0	0	3
4	25WPE204	Electrical Machines-I	40	60	100	3	0	0	3
PRACTICAL									
5	25WPE205	Electric Circuits and Electronic Devices Laboratory	60	40	100	0	0	3	1.5
TOTAL					500	12	0	3	13.5

Third Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE301	Electrical Machines-II	40	60	100	3	0	0	3
2	25WPE302	Power Generation, Transmission and Distribution	40	60	100	3	0	0	3
3	25WPE303	Linear Integrated Circuits	40	60	100	3	0	0	3
4	25WPE304	Electrical and Electronic Measurements	40	60	100	3	0	0	3
PRACTICAL									
5	25WPE305	Electrical Machines Laboratory	60	40	100	0	0	3	1.5
TOTAL					500	12	0	3	13.5

Fourth Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE401	Control Systems Engineering	40	60	100	3	0	0	3
2	25WPE402	Power System Analysis	40	60	100	3	0	0	3
3	25WPE403	Power Electronics	40	60	100	3	0	0	3
4	***E1***	***Elective – I***	40	60	100	3	0	0	3
PRACTICAL									
5	22WPE404	Power Systems and Power Electronics Laboratory	60	40	100	0	0	3	1.5
TOTAL					500	12	0	3	13.5

Fifth Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE501	Power System Operation and Control	40	60	100	3	0	0	3
2	25WPE502	Power System Protection	40	60	100	3	0	0	3
3	25WPE503	HVDC Transmission System	40	60	100	3	0	0	3
4	25WPE504	Microprocessor and Microcontroller Programming	40	60	100	3	0	0	3
5	***E2***	***Elective – II***	40	60	100	3	0	0	3
TOTAL					500	15	0	0	15

Sixth Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE601	Project Management and Entrepreneurship	40	60	100	3	0	0	3
2	25WPE602	Industrial Drives and Control	40	60	100	3	0	0	3
3	25WPE603	Electrical Machine Design	40	60	100	3	0	0	3
4	25WPE604	Renewable Energy Sources	40	60	100	3	0	0	3
5	***E3***	***Elective – III***	40	60	100	3	0	0	3
TOTAL					600	15	0	0	15

Seventh Semester

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
THEORY									
1	25WPE701	Electric Vehicle Technology	40	60	100	3	0	0	3
2	***E4***	***Elective – IV***	40	60	100	3	0	0	3
PRACTICAL									
4	25WPE702	Project Work	60	40	100	0	0	16	8
TOTAL					300	6	0	16	14

TOTAL NO. OF CREDITS : 98

CREDITS PER SEMESTER							TOTAL NO OF CREDITS
I	**II**	**III**	**IV**	**V**	**VI**	**VII**	
13.5	**13.5**	**13.5**	**13.5**	**15**	**15**	**14**	**98**

LIST OF ELECTIVES:

ELECTIVE – I **SEMESTER – IV**

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
1	25WPE4E1	Power Quality Engineering	40	60	100	3	0	0	3
2	25WPE4E2	Energy Auditing and Management	40	60	100	3	0	0	3
3	25WPE4E3	Power System Economics	40	60	100	3	0	0	3
4	25WPE4E4	Restructured Power Systems	40	60	100	3	0	0	3
5	25WPE4E5	Electrical Safety and Quality Management	40	60	100	3	0	0	3

ELECTIVE – II **SEMESTER – V**

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
1	25WPE5E1	Biomedical Instrumentation	40	60	100	3	0	0	3
2	25WPE5E2	Thermal Power Plant Instrumentation	40	60	100	3	0	0	3
3	25WPE5E3	MEMS and NEMS	40	60	100	3	0	0	3
4	25WPE5E4	IoT for Electrical Engineering	40	60	100	3	0	0	3
5	25WPE5E5	Soft Computing Techniques	40	60	100	3	0	0	3

ELECTIVE – III **SEMESTER - VI**

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
1	25WPE6E1	Smart Grid Technology	40	60	100	3	0	0	3
2	25WPE6E2	Energy Storage Technology	40	60	100	3	0	0	3
3	25WPE6E3	Special Machines and Controllers	40	60	100	3	0	0	3
4	25WPE6E4	FACTS Controllers	40	60	100	3	0	0	3
5	25WPE6E5	Automotive Electronics for Electrical Engineering	40	60	100	3	0	0	3

ELECTIVE - IV **SEMESTER – VII**

Sl. No.	Course Code	Course Title	Sessional Marks	Final Exam Marks	Total Marks	Credits			
						L	T	P	C
1	25WPE7E1	Design of Electric Vehicles Charging Systems	40	60	100	3	0	0	3
2	25WPE7E2	Testing of Electric Vehicles	40	60	100	3	0	0	3
3	25WPE7E3	Grid Integration of Electric Vehicles	40	60	100	3	0	0	3
4	25WPE7E4	Intelligent Control of Electric Vehicles.	40	60	100	3	0	0	3
5	25WPE7E5	Hybrid Electric and Fuel Cell Vehicles	40	60	100	3	0	0	3

Programme Co-ordinator **HoD / EEE**

25WPE1Z1	APPLIED MATHEMATICS I *(Common to Civil, Mech & ECE* Branches*)*	SEMESTER I			
PREREQUISITES		**L**	**T**	**P**	**C**
NIL		**3**	**0**	**0**	**3**

Course Objectives	This course mainly deals with topics such as linear algebra, single variable calculus and numerical methods and plays an important role in the understanding of engineering science.	
UNIT – I	**LINEAR ALGEBRA**	**9 Periods**
Consistency of System of Linear Equations, Eigenvalues and eigenvectors, Diagonalization of matrices by orthogonal transformation, Cayley-Hamilton Theorem, Quadratic form to canonical forms.		
UNIT – II	**DIFFERENTIAL CALCULUS**	**9 Periods**
Radius of curvature, Centre of curvature, Circle of curvature, Evolutes of a curve, Envelopes		
UNIT – III	**INTEGRAL CALCULUS**	**9 Periods**
Evaluation of definite and improper integrals, Applications: surface area and volume ofr evolution (Cartesian coordinates only).		
UNIT – IV	**NUMERICAL SOLUTION OF EQUATIONS**	**9 Periods**
Algebraic and Transcendental equation: Fixed point iteration method, Bisection method, Newton-Raphson method, Simultaneous equation: Gauss elimination method, Gauss-Jordan method, Gauss Seidal method.		
UNIT – V	**NUMERICAL INTERPOLATION**	**9 Periods**
Equal interval: Newton's forward and Backward difference interpolation formulae, Gauss forward and Backward difference interpolation formulae, Unequal interval: Lagrange's interpolation, Newton's divided difference interpolation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	*Veerarajan T., "**Engineering Mathematics I"**, Tata McGraw-Hill Education (India)Pvt. Ltd, New Delhi, Edition 1, 2017.*
2	*P. Kandasamy, K. Thilagavathy, K. Gunavathi, "**Numerical Methods"**, S. Chand & Company, 3rd Edition, Reprint , 2013.*

REFERENCE BOOK

1	*B.S.Grewal, "**Higher Engineering Mathematics"**, Khanna Publishers, 44th Edition, 2021.*
2	*David C.Lay, **"Linear Algebra and Its Application"**, Pearson Publishers, 6thEdition, 2021.*
3	*Howard Anton, **"Elementary Linear Algebra"**,11thEdition, Wiley Publication, 2013.*
4	*Narayanan.S and Manicavachagom Pillai. T.K. – **Calculus Vol I and Vol II,** S.chand & Co, Sixth Edition, 2016.*
5	*S.S. Sastry, "**Introductory methods of numerical analysis"**, PHI, New Delhi, 5th Edition, 2015.*
6	*Ward Cheney, David Kincaid, **"Numerical Methods and Computing",** Cengage Learning**,** Delhi, 7th Edition 2013.*
7	*Jain R.K. and Iyengar S.R.K., - **Advanced Engineering Mathematics**, Narosa Publications, Eighth Edition, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Use the essential tool of matrices and linear algebra in a comprehensive manner.	K3
CO2	Explain the fallouts of circle of curvature, evolute and envelops that is fundamental to application of analysis to Engineering problems.	K3
CO3	Interpret the integral calculus to notions of definite and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.	K3
CO4	Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to polynomial and transcendental equations.	K3
CO5	Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations.	K3

25WPE1Z2	**ENVIRONMENTAL SCIENCE AND ENGINEEREING** *(Common to CIVIL, MECH & ECE Branches)*	**SEMESTER I**

PREREQUISITES	**L**	**T**	**P**	**C**
NIL	**3**	**0**	**0**	**3**

Course Objectives	The course is aimed at creating awareness among the students and also inseminates the critical ideas of preserving environment.	
UNIT – I	**ENVIRONMENTAL ENERGY RESOURCES**	**9 Periods**
Food-effects of modern agriculture, fertilizers, pesticides, eutrophication & biomagnifications-Energy resources: renewable resources - Hydro Energy, Solar & Wind. Non-renewable resources – Coal and Petroleum - harnessing methods.		
UNIT – II	**ECO SYSTEM AND BIODIVERSITY**	**9 Periods**
Eco system and its components - biotic and abiotic components. Biodiversity: types and values of biodiversity, hot spots of biodiversity, endangered and endemic species, conservation of biodiversity: In situ and ex situ conservation. Threats to biodiversity-destruction of habitat, habit fragmentation, hunting, over exploitation and man-wildlife conflicts. The IUCN red list categories.		
UNIT – III	**ENVIRONMENTAL POLLUTION**	**9 Periods**
Air pollution, classification of air pollutants – sources, effects and control of gaseous pollutants SO_2, NO_2, H_2S, CO, CO_2 and particulates. Water pollution - classification of water pollutants, organic and inorganic pollutants, sources, effects and control of water pollution. Noise pollution - decibel scale, sources, effects and control.		
UNIT – IV	**ENVIRONMENTAL THREATS**	**9 Periods**
Global warming-measure to check global warming - impacts of enhanced Greenhouse effect, Acid rain-effects and control of acid rain, ozone layer depletion- effects of ozone depletion, disaster management - flood, drought, earthquake and tsunami.		
UNIT – V	**SOCIAL ISSUES AND ENVIRONMENT**	**9 Periods**
Water conservation, rain water harvesting, e-waste management, Pollution Control Act, Wild life Protection Act. Population growth- exponential and logistic growth, variation in population among nations, population policy. Women and Child welfare programs. Role of information technology in human and health, COVID-19 - effects and preventive measures.		
Contact Periods: **Lecture:45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**		

TEXT BOOK:

1	*Sharma J.P., **"Environmental Studies"**, 4th Edition, University Science Press, New Delhi, 2016.*
2	*Anubha Kaushik and C.P.Kaushik, **"Environmental Science and Engineering"**, 7th Edition, New age international publishers, New Delhi, 2021.*

REFERENCES:

1	*A k de, **"Environmental Chemistry"**, 8th edition, New age international publishers, 2017.*

2	*G. Tyler miller and scott e. Spoolman,* ***"Environmental Science"****, cengage learning india pvt. Ltd., delhi,* *2014.*
3	*Erach Bharucha,* ***"Textbook of Environmental Studies"****, Universities press (I) pvt, Ltd., Hydrabad, 2015.*
4	*Gilbert M. Masters,* ***"Introduction to Environmental Engineering and Science"****, 3rd Edition, Pearson Education, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recognize and understand about the various environmental energy resources and the effective utility of modern agriculture.	K2
CO2	Acquire knowledge about the interaction of biosphere with environment and conservation methods of bio diversity.	K2
CO3	Be aware of the sources of various types of pollution, their ill effects and preventive methods.	K2
CO4	Identify and take the preventive measures to control the environmental threats and effects of Global warming, Ozone depletion, Acid rain, and natural disasters.	K2
CO5	Demonstrate an idea to save water and other issues like COVID -19.	K2

25WPE103	PROGRAMMING IN C	SEMESTER I			
PREREQUISITES		**L**	**T**	**P**	**C**
NIL		**3**	**0**	**0**	**3**

Course Objectives	1. To Familiarize with Computer and Programming fundamentals 2. To understand Data types in C and Flow control statements 3. To outline Functions, Arrays, Pointers and Strings 4. To recognize Bitwise Operators, Pre-processor Directives, Structures and Unions 5. To build Structures, Unions, List Processing, Input and Output functions.	
UNIT – I	**COMPUTER AND PROGRAMMING FUNDAMENTALS**	**9 Periods**
Computer fundamentals –Anatomy of a computer: CPU, Memory, I/O – Introduction to software – Generation and classification of programming languages – Compiling – Linking and loading a program – Translator – loader – linker – develop a program – software development – Introduction to OS –Types of OS – Algorithms – Structured programming concept.		
UNIT – II	**DATA TYPES AND FLOW OF CONTROL**	**9 Periods**
An overview of C – Programming and Preparation – Program Input /Output – Variables – Expressions, and Assignment, The use of #include, printf(), scanf() – Lexical elements, operators - The fundamental data types – Flow of control		
UNIT – III	**FUNCTIONS, ARRAYS, POINTERS AND STRINGS**	**9 Periods**
Functions and storage classes - Arrays – Pointers – Call by reference – Relationship between Arrays and Pointers – Pointer arithmetic and element size – Arrays as function argument – Dynamic memory allocation – Strings – String handing functions – Multidimensional Arrays.		
UNIT – IV	**ARRAY OF POINTERS, BITWISE OPERATORS, PREPROCESSOR DIRECTIVES**	**9 Periods**
Arrays of Pointers – Arguments to main () - Functions as Arguments – Array of Pointers to Functions - Type qualifiers. -Bitwise operators and expressions – Masks – Software tools – Packing and unpacking – Enumeration types – The preprocessor directives.		
UNIT – V	**STRUCTURES AND UNIONS, I/O AND FILE OPERATIONS**	**9 Periods**
Structures and Unions – Operator precedence and associativity – Bit fields – Accessing bits and bytes - Input and Output functions – File Processing Functions – Environment variables – Use of make and touch.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Pradip Dey, Manas Ghosh, "**Computer Fundamentals and Programming in C**", Second Edition, Oxford University Press, 2013.*
2	*Ashok H. Kamthane, Amit Ashok Kamthane, "**Programming in C**", Third Edition, Pearson, 2015.*

REFERENCES:

1	*Stephen G. Kochan, "**Programming in C-A complete introduction to the C programming language"**, Third Edition, Sams Publication, 2004.*
2	*Yashavant P. Kanetkar, "**Let Us C**", 13th edition, BPB Publications, 2013.*
4	*Stephen Prata, "**C Primer Plus**", Fifth Edition, Sams Publishing, 2005.*
3	*Brian W. Kernighan and Dennis Ritchie, "**The C Programming Language**", Second Edition, Prentice Hall Software Series, 1988.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the fundamentals of computer systems, programming concepts, C language structure, data types, and control flow, including the role of compilers, linkers, operating systems, and structured programming principles.	K2
CO2	Apply C programming constructs such as variables, operators, control statements, functions, arrays, and basic I/O operations to develop simple and modular C programs following structured programming practices.	K3
CO3	Analyze the use of functions, pointers, arrays, strings, storage classes, and dynamic memory allocation in C.	K4
CO4	Demonstrate the use of advanced C features such as arrays of pointers, function pointers, bitwise operators, preprocessor directives, and enumeration types to implement efficient and optimized programs.	K5
CO5	Design and develop complete C applications by integrating algorithms, control structures, functions, pointers, structures, file operations, and software development tools.	K6

25WPE104	ELECTRIC CIRCUIT THEORY	SEMESTER I

PREREQUISITES	L	T	P	C
NIL	3	0	0	3

Course Objectives	To gain knowledge in basic concepts of circuit theory and finally be able to analyze and synthesize electric circuits	
UNIT – I	**DC AND AC CIRCUIT ANALYSIS**	**9 Periods**
Ohm's law and Kirchhoff's Laws –Form Factor and Peak Factor derivation for alternating waveforms - R, L, C series-parallel circuits - Star-delta transformation - Source transformations - Mesh and nodal methods –Power factor - Real, reactive and apparent powers.		
UNIT – II	**NETWORK THEOREMS AND POLYPHASE CIRCUITS**	**9 Periods**
Superposition theorem – Thevenin's and Norton's theorems - Maximum power transfer theorem - Reciprocity theorem. Three phase system - Interconnection of three- phase sources and loads - Balanced and unbalanced circuits - Power measurement.		
UNIT – III	**RESONANCE AND COUPLED CIRCUITS**	**9 Periods**
Resonance in series and parallel circuits – frequency response - derivation of bandwidth - Introduction to coupled circuits – Mutual inductance – Coefficient of coupling - Dot rule - Problems.		
UNIT – IV	**TRANSIENTS**	**9 Periods**
Transient response of RL, RC and RLC circuits with DC excitation – Sinusoidal response of RL, RC, RLC circuits.		
UNIT – V	**TWO PORT NETWORKS**	**9 Periods**
Two port networks - Impedance and Admittance parameters – Transmission and inverse transmission parameters – Hybrid and inverse hybrid parameters - Application.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Sudakar A. and Shyam Mohan S.Palli,* ***"Circuits and Networks (Analysis and Synthesis)",*** *Tata McGraw Hill Book Co., New Delhi, III Ed., 2017.*
2	*Charles K. Alexander, Matthew N.O. Sadiku,* ***"Fundamentals of Electric Circuits",*** *McGraw Hill Book Co., 7 Ed. 2020.*

REFERENCES:

1	*Hayt W.H and Kemmerley J.E, **"Engineering Circuit Analysis"**, Tata McGraw Hill Book Co., V Ed., 2019.*
2	*C.P. Kuriakose, **"Circuit Theory: Continuous and Discrete – time systems – Elements of Network Synthesis",** PHI, Delhi, 2018.*
3	*Gangadhar K.A., **"Circuit Theory"**, Khanna Publishers, II Ed., 2019.*
4	*M.E.VanValkenburg, **"Network Analysis"**, PHI, Delhi, 2019.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the fundamental laws and concepts of electric circuits, including Ohm's law, Kirchhoff's laws, AC waveform parameters, resonance, transient behavior	K2
CO2	Apply circuit analysis techniques such as mesh and nodal analysis, network theorems, resonance conditions, and transient response equations to solve DC, AC, and three-phase circuit problems	K3
CO3	Analyze single-phase and polyphase circuits to determine voltage, current, power, power factor, resonance characteristics, and transient responses under various operating conditions.	K4
CO4	Evaluate the suitability of network theorems, source transformations, and two-port network parameters for simplifying complex circuits and optimizing power transfer and system performance.	K5
CO5	Design and model electrical networks involving resonance, transient conditions, three-phase systems, and two-port networks to meet specified electrical performance criteria.	K6

25WPE105	PROGRAMMING IN C LABORATORY	SEMESTER I

PREREQUISITES	L	T	P	C
NIL	0	0	3	1.5

Course Objectives	Upon completion of this course, the Students will be familiar with 1. Data types in C and Flow control statements 2. Functions, Arrays, Pointers and Strings 3. Dynamic memory allocation and command line arguments 4. Bitwise Operators, Preprocessor Directives, Structures and Unions 5. Structures, List Processing, Input and Output.

PRACTICALS EXERCISES ILLUSTRATING THE FOLLOWING CONCEPTS:

1 Operators, Expressions and I/O formatting
2 Decision Making and Looping
3 Arrays and Strings
4 Functions and Recursion
5 Pointers
6 Dynamic Memory Allocation
7 Structures
8 Unions
9 Files
10 Command line arguments

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 15 Periods Total: 45 Periods

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply operators, expressions, formatted input/output, decision-making statements, and looping constructs to develop basic C programs for solving computational problems.	K3
CO2	Develop C programs using arrays, strings, and functions, including recursion, to process data efficiently and modularize program logic.	K4
CO3	Evaluate the effectiveness of structures, unions, and file handling techniques in organizing data, storing records, and performing persistent data operations.	K5
CO4	Design and implement complete C applications integrating functions, pointers, dynamic memory allocation, structures, file operations, and command-line arguments to solve real-world programming problems.	K6
CO5	Use modern programming tools such as IDEs, debuggers, and online learning resources to design, implement, test, and continuously improve C programs, demonstrating self-learning ability and adaptability to emerging technologies.	K3

25WPE2Z1	APPLIED MATHEMATICS II *(Common to Mech & ECE Branches)*	SEMESTER II			
PREREQUISITES		**L**	**T**	**P**	**C**
NIL		**3**	**0**	**0**	**3**
Course Objectives	To focus on differential equations and Numerical Techniques which is important for comprehending engineering science.				
UNIT–I	**ORDINARY DIFFERENTIAL EQUATIONS**	**9 Periods**			
Higher order linear differential equations with constant coefficients – variable coefficients: Cauchy Euler equation, Cauchy-Legendre equation-Method of variation of parameters.					
UNIT–II	**PARTIAL DIFFERENTIAL EQUATIONS**	**9 Periods**			
Formation of partial differential equations – First order partial differential equations: Standard types and Lagrange's linear equation – Homogeneous linear partial differential equations of second and higher order with constant coefficients.					
UNIT–III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9 Periods**			
Numerical Differentiation (using Newton's interpolation formula) – Numerical integration: Trapezoidal rule and Simpson's rules (Both single and double integrals).					
UNIT–IV	**NUMERICAL SOLUTION OF FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS**	**9 Periods**			
Single Step Methods: Taylor's series Method-Euler's and modified Euler's methods–Runge– Kutta method of fourth order Multi Step methods - Milne's and Adam's predicator-corrector methods					
UNIT–V	**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**	**9 Periods**			
Finite difference solution of two-dimensional Laplace equation and Poisson equation- Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods) –Finite difference explicit method for one dimensional wave equation.					
ContactPeriods: **Lecture:45PeriodsTutorial:0Periods** **Practical:0Periods Total:45 Periods**					

TEXTBOOK

1	*Veerarajan.T, **"Engineering Mathematics"**, Tata McGraw Hill Education (India) Private Limited, New Delhi, 2018*
2	*P. Kandasamy, K. Thilagavathy, K. Gunavathi, **"Numerical Methods"**, S. Chand & Company, 3rd Edition, Reprint 2013.*

REFERENCES

1	*B.S.Grewal,* ***"Higher Engineering Mathematics"****, Khanna Publishers, New Delhi, 45th Edition, 2024*
2	*SrimantaPal,* ***"Numerical Methods Principles, Analyses and Algorithms"****, Oxford University Press, New Delhi, IEdition 2012.*
3	*Raisinghania.M..D,* ***"Ordinary And Partial Differential Equations"****, 20th Edition, S. ChandPublishing,2020*
4	*S.Larsson and V.Thomee,* ***"Partial Differential Equations with Numerical Methods"****, Springer, 2003, 2nd printing 2008 Edition*

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Solve higher order linear differential equation with constant and variable coefficients and simultaneous differential equation.	K3
CO2	Form partial differential equations and find solutions of first and higher order partial differential equations	K3
CO3	Obtain approximate solutions for transcendental equations and problems on interpolation, differentiation, integration.	K3
CO4	Find the numerical solutions of first order ordinary differential equations using single and multi-step techniques.	K3
CO5	Solve second order partial differential equations using explicit and implicit methods.	K3

25WPE202	ELECTRONIC DEVICES AND CIRCUITS	SEMESTER II

PREREQUISITES	L	T	P	C
NIL	3	0	0	3

UNIT – I	BASIC SEMICONDUCTOR DEVICES AND APPLICATIONS	9Periods

PN diode: VI characteristics–transition and diffusion capacitance–reverse recovery time– Applications: Half-wave and Full-wave rectifiers with filters–Clipping and clamping circuits–Avalanche and Zener breakdown-Zener diodes– Applications.

UNIT – II	BI-POLAR JUNCTION TRANSISTORS	9Periods

BJT: Structure–operation and characteristics– as an amplifier and switch–DC operating point – base, emitter and voltage-divider bias – Stability factor –Miller's theorem.

UNIT - III	BJT AMPLIFIERS	9Periods

BJT amplifier: operation –AC equivalent circuits–CE, CC, CB configurations-multistage–RC coupled–transformer coupled–Darlington and differential amplifiers– basics of frequency response – Low–high and total Frequency response –Power amplifiers –operation – characteristics– parameters of Class A, AB, B and C amplifiers

UNIT – IV	FIELD-EFFECT TRANSISTORS	9Periods

JFET: Structure, operation and characteristics with parameters–biasing configurations – MOSFET: Structure–types (Depletion and Enhancement)–operation and characteristics–biasing configurations– Stability factor - VMOSFET–CMOS technology.

UNIT – V	FEEDBACK TECHNIQUES AND OSCILLATORS	9Periods

Concepts of feedbacks –Negative feedback: shunt and series feedback- Positive feedback: Wien Bridge and RC phase shift oscillators.

Contact Periods:
Lecture: 45 PeriodsTutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK :

1	*ThomasL.Floyd, "**ElectronicDevices**",10th Edition.,Prentice Hall Inc.,2018.*
2	*RobertBoylestad, **"ElectronicDevicesandCircuitTheory"**,11th Edition, Pearson,2014.*

REFERENCES:

1	*Jacob Millman,Christos C Halkias and SatyabrataJIT,"**ElectronDevicesand Circuits**", 4th Ed.,TataMcGrawHill,2015.*
2	*Allen Mottershead, "**Electronic Devices and Circuits, An Introduction**", Eastern Economy Ed.,Prentice-HallofIndia,2009.*

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	**Explain** the basic operation and characteristics of semiconductor devices such as diodes, BJTs, JFETs, and MOSFETs.	K2
CO2	**Apply** appropriate biasing methods to set and analyze the operating point of transistor circuits.	K3
CO3	**Analyse** the performance and frequency response of BJT and FET amplifiers, including power amplifiers.	K4
CO4	**Apply** feedback principles to determine changes in amplifier performance and identify the conditions required for oscillations in practical circuits.	K3
CO5	**Apply** standard circuit design techniques to construct rectifiers, clipping / clamping circuits, amplifiers, feedback circuits, and oscillators for given specifications.	K3

25WPE203	DIGITALCIRCUITS	SEMESTER II

PREREQUISITES	L	T	P	C
NIL	3	0	0	3

UNIT – I	BOOLEAN ALGEBRA AND LOGIC GATES	9Periods

Binary Systems, Boolean Algebra and Logic gates – Boolean functions - Canonical and Standard Forms - Digital Logic gates – Integrated circuits. Gate level minimization – Map methods- NAND and NOR Implementation.

UNIT – II	COMBINATIONAL LOGIC	9Periods

Combinational circuits - Analysis and Design Procedure- Binary adder subtractor - Decimal adder – Binary multiplier – Magnitude comparator – Decoders – Encoders – Multiplexers.

UNIT – III	SYNCHRONOUS SEQUENTIAL LOGIC	9Periods

Sequential circuits- Latches – Flip flops – Analysis of Clocked Sequential Circuits – State Reduction and Assignment - Design Procedure.

UNIT - IV	ASYNCHRONOUS SEQUENTIAL LOGIC	9Periods

Asynchronous Circuits - Analysis Procedure - Circuits with Latches – Reduction of State Flow Tables – Race Free State Assignment – Hazards - Design Example.

UNIT – V	REGISTERS, COUNTERS AND MEMORY	9Periods

Registers, Shift Registers, Ripple Counters, Synchronous Counters, Random Access Memory, Memory Decoding, Error Detection and Correction, Read Only Memory, Programmable Logic Array. Register Transfer Level Introduction, Algorithmic State Machines, Binary Multiplier.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1	*Morris Mano. M,**"Digital Design"** Pearson Education, New Delhi, 6thEd., 2018.*
2.	*Floyd Thomas L., **"Digital fundamentals"** Pearson Education, New Delhi, 11th Ed., 2017.*

REFERENCES:

1	*Ronald J. Tocci, Neal S Widmer, Gregory L Moss, **"Digital Systems: Principles and Applications",** Prentice Hall, 12thEd., 2017*
2	*Floyd Thomas L., **"Digital fundamentals"** Pearson Education, New Delhi, 11thEd.,2015.*
3	*Charles H.Roth, **"Fundamentals of Logic Design"** 7thEd., Cl-Engineering, 2013.*

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain Boolean algebra, logic gates, and methods for simplifying logic functions.	K2
CO2	Apply combinational logic design techniques to implement arithmetic and data-handling circuits.	K3
CO3	Analyze sequential circuits using latches, flip-flops, and state diagrams to determine system behavior.	K4
CO4	Apply design procedures to develop asynchronous circuits and identify hazards and race conditions.	K3
CO5	Analyze and interpret the operation of registers, counters, and memory systems.	K4

25WPE204	ELECTRICAL MACHINES - I	SEMESTER II			
PREREQUISITES		**L**	**T**	**P**	**C**
NIL		**3**	**0**	**0**	**3**

UNIT – I	PRINCIPLES OF ELECTROMECHANICAL ENERGY CONVERSION	9Periods

Energy in magnetic system – Field energy and co energy - Force and torque equations-eddy currents and eddy current losses – flux distribution curve in the air gap – Singly and multiply excited magnetic field systems - mmf of distributed ac windings – Winding Inductances - Rotating Magnetic Field and mmf waves - Magnetic saturation and leakage fluxes.

UNIT – II	DC GENERATORS	9Periods

Constructional details and principle of operation – Armature winding -Emf equation – Types- Armature reaction: Effects - demagnetizing & cross magnetizing ampere-turns – compensating windings – interpoles; Commutation – Characteristics of DC generators - losses and efficiency -Parallel operation of dc generators- Applications.

UNIT – III	DC MOTORS	9Periods

Constructional details and principle of operation- back emf – Types of dc motors - Torque equation, power flow diagram, losses and efficiency – Electrical and mechanical characteristics of different types of motors – Starters – Speed control methods – Types of Electric braking.

UNIT – IV	TRANSFORMERS	9Periods

Principle of operation – Types and constructional features of single phase and three phase transformers –EMF equation - Phasor diagram – Transformers on load - Equivalent circuit – Voltage Regulation and efficiency- All day efficiency - Three phase transformer connections – Scott connection – Parallel operation of three phase transformers – Inrush current phenomenon and its prevention - Auto transformers, Off-load and on-load tap changing transformer-Isolation Transformers.

UNIT – V	TESTING OF DC MACHINES AND TRANSFORMERS	9Periods

DC machines: Brake test, field test, Retardation test, Swinburne's test, Hopkinson's test. Transformers: – Phasing, Identification and Polarity test on transformer winding - Sumpner's test.

Contact Periods:
Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1	*Nagrath J. and D. P. Kothari,* ***"Theory of Electric Machines",*** *5^{th} edition, Tata McGraw Hill, 2017.*
2	*Fitzgerald A. E., C. Kingsley and S. Umans,* ***"Electric Machinery",*** *7/e, McGraw Hill, 2020.*

REFERENCES:

1	*Bimbra P. S., **"Electrical Machinery",** 7/e, Khanna Publishers, 2021.*
2	*Theraja B. L., **"A Textbook of Electrical Technology",** S.Chand, New Delhi. Reprint 2019.*
3	*Abhijith Chakrabarti, Sudipta Debnath, **"Electrical Machines",** McGraw Hill Education, New Delhi, 2015.*
4	*Deshpande M. V., **"Electrical Machines",** Prentice Hall India, New Delhi, 2011.*

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the principles of electromechanical energy conversion and the operation of DC Machines and Transformers.	K2
CO2	Derive the expressions for Emf, Torque and speed of different types of DC Machines.	K3
CO3	Apply basic principles to calculate emf, regulation and efficiency of different types of transformers	K3
CO4	Analyze the performance characteristics of different types of DC Machines and Transformers.	K4
CO5	Obtain the performance of different DC machines and Transformers by conducting suitable tests.	K3

25WPE205	ELECTRIC CIRCUITS AND ELECTRONIC DEVICES LABORATORY	SEMESTER II

PREREQUISITES	L	T	P	C
NIL	0	0	3	1.5

List of Experiments:

1. Verification of Ohm'sLaw and Kirchhoff's laws.
2. Verification of network theorems.
3. Analysis of First order R-Land R-C Circuits / Second order RLC Circuits
4. Measurement of average, rms, form and peak factor of time varying signals
5. Three Phase power measurement
6. Semiconductor diode characteristics.
7. Zener diode characteristics and voltage regulation.
8. Transistor characteristics –common emitter mode and common base mode.
9. Characteristics of UJT and generation of sawtooth waveforms.
10. Characteristics of FET.

Contact Periods:
Lecture:0Periods Tutorial:0Periods Practical:45Periods Total:45Periods

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Verify the basic laws of circuit the ory and various network theorems.	K4
CO2	Infer the characteristics of basic semiconductor devices.	K4
CO3	Measure the real and reactive power in three phase networks.	K4
CO4	Analyze the circuits and devices using simulation tool.	K4
CO5	Determine the parameters of electronic circuits.	K4

25WPE301	ELECTRICAL MACHINES-II	SEMESTER III

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To acquire the knowledge of working principles and performance of rotating AC machinery and special machines.	
UNIT – I	**SYNCHRONOUS GENERATOR**	**(9 periods)**
Construction – Rotor types – emf equation – Synchronous reactance – Armature reaction-Voltage regulation – EMF, MMF, ZPF –Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input – Two reaction theory – Determination of direct and quadrature axis synchronous reactance using slip test – Operating characteristics.		
UNIT – II	**SYNCHRONOUS MOTOR**	**(9 periods)**
Principle of operation – Torque equation – Operation on infinite bus bars - V and inverted V curves – Power input and power developed equations – Starting methods – Current loci for Constant power input, constant excitation and constant power developed - Necessity of Damper windings - Applications.		
UNIT – III	**THREE PHASE INDUCTION MOTOR**	**(10 periods)**
Construction – Principle –Rotor types - Slip – Equivalent circuit – Slip-torque characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests -Circle Diagram- Separation of no load losses – Double cage rotors. Types of starters: Rotor resistance, Autotransformer and Star-delta starters – Speed control: Voltage control, Frequency control and pole changing – Cascaded Connection-Braking of three phase induction motor: Plugging, dynamic braking and regenerative braking.		
UNIT – IV	**SINGLE PHASE INDUCTION MOTORS**	**(9 periods)**
Constructional details of single-phase induction motor – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor tests – Performance analysis – Starting Methods - Shaded pole induction motor - Capacitor-start capacitor run induction motor.		
UNIT – V	**SPECIAL MACHINES**	**(8 periods)**
Linear induction motor - Hysteresis motor - AC series motor-Switched Reluctance Motor-Stepper motor –Permanent magnet A.C motor (BLDC and PMSM) (Qualitative treatment only)- Magnetic levitation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*D. P. Kothari and I. J. Nagrath,* ***"Electric Machines"****, Tata McGraw-Hill, V Edition, 2017.*
2	*A. E. Fitzgerald, Charles Kingsley Jr. and Stephen D. Umans,* ***"Electric Machinery"****, McGraw-Hill Education, VII Edition, 2013.*

REFERENCES :

1	*Jan A. Melkebeek,* ***"Electrical Machines and Drives: Fundamentals and Advanced Modelling"****, Springer International Publishing, 2018.*
2	*S. K. Sahdev,* ***"Electrical Machines"****, Cambridge University Press, 2017.*
3	*P. S. Bimbhra,* ***"Electrical Machinery"****, Khanna Publishers, VII Edition, 2011.*
4	*B. L. Theraja and A. K. Theraja,* ***"A Textbook of Electrical Technology – Volume II (AC & DC Machines)"****, S. Chand & Company, Revised Edition 2015.*
5	*E. G. Janardanan,* ***"Special Electrical Machines"****, PHI Learning Private Limited, 2014.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the operating principle of rotating AC machines.	K2
CO2	Familiarize the characteristics of synchronous and induction machines.	K2
CO3	Apply the knowledge of Induction and Synchronous machines for specific applications	K3
CO4	Execute speed control and starting methods for various AC motors.	K3
CO5	Familiarize special electrical machines and their applications	K4

25WPE302	POWER GENERATION, TRANSMISSION AND DISTRIBUTION	SEMESTER III

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To know the various components of Power Systems and design an electric power network in electrical and mechanical point of view.	
UNIT – I	**GENERATION OF ELECTRICAL ENERGY**	**(9 Periods)**
Structure of electric power system – Working and Site Selection of: Conventional Energy Generation- Thermal, Hydro, Pumped storage plant, Nuclear, Diesel and Gas turbine power plant- Non-Conventional Energy Generation- Wind, Tidal, Solar, Geothermal, Biogas and Fuel Cell. Comparison of different types of power plants.		
UNIT – II	**TRANSMISSION LINE PARAMETERS AND DESIGN**	**(9 Periods)**
Types of conductor- conductor materials, Line Resistance, inductance and capacitance of solid, stranded and bundled conductors-configuration –Symmetrical and unsymmetrical spacing – Transposition of lines – Concept of GMR and GMD –Skin and proximity effect – Interference with neighboring communication circuits. Mechanical design of transmission line-Line supports- Sag and tension calculations considering the effect of ice and wind loading-stringing chart.		
UNIT – III	**MODELLING AND PERFORMANCE OF TRANSMISSION LINES**	**(9 Periods)**
Classification of Transmission lines-regulation and efficiency-short Transmission lines effect of load power factor on transmission efficiency and regulation of line-Medium Transmission line: end condenser method, nominal-T and π methods. Ferranti effect-Long Transmission line: Analysis by Rigorous method, Surge Impedance Loading- Power flow through a Transmission line- Concept of Power circle diagram-Corona: Phenomenon, Corona loss, methods of reducing Corona.		
UNIT – IV	**LINE INSULATORS AND POWER CABLES**	**(9 Periods)**
Insulator materials-types of insulators- potential distribution across string of suspension insulators - string efficiency and methods of improving string efficiency. Cables: general construction of cables-insulation resistance of power cables-capacitance and insulation stress in cables, sheathing-grading of cables, tan and power factor- heating of cable- breakdown of cables.		
UNIT – V	**SUBSTATION AND DISTRIBUTION SYSTEM**	**(9 Periods)**
Substation: Classification-Bus-Bar Arrangements in substation. Distribution system: Design consideration-classification of DS. DC distributor fed at one end, both ends, ring main- 3-wireDC distribution system A.C. Distribution: A.C. Distributors with concentrated loads- 3-phase 4- wire star connected load circuits- consequence of disconnecting neutral in a 3-phase 4- wire system.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	C. L. Wadhwa, ***"Electrical Power Systems"***, New Age International, VIII Edition, 2022.
2	*D. P. Kothari and I. J. Nagrath,* ***"Power System Engineering"****, McGraw-Hill Education, III Edition, 2019.*

REFERENCES :

1	*P. Karampelas,* ***"Electricity Distribution: Intelligent Solutions for Electricity Transmission and Distribution Networks"****, Springer, I Edition, 2016.*
2	*J. B. Gupta,* ***"Transmission and Distribution of Electrical Power"****, S. K. Kataria & Sons, X Edition, 2014.*
3	*A. Chakrabarti, M. L. Soni, P. V. Gupta and U. S. Bhatnagar,* ***"A Textbook on Power System Engineering"****, Dhanpat Rai Publishing Company, New Edition, 2015.*
4	*V. K. Mehta and Rohit Mehta,* ***"Principles of Power Systems"****, S. Chand & Company, I Edition, 2004.*
5	*S. N. Singh,* ***"Electric Power Generation, Transmission and Distribution"****, Prentice Hall of India, II Edition, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the structure of the power system and different energy sources.	K2
CO2	Evaluate the parameters of the transmission line for different configurations.	K4
CO3	Develop a model and assess the performance of overhead lines.	K3
CO4	Classify different types of distribution systems and evaluate the performance of the Distribution network.	K5
CO5	Analyze transmission and distribution network with respect to electrical and mechanical aspects.	K4

25WPE303	LINEAR INTEGRATED CIRCUITS	SEMESTER III

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the concept of IC fabrication technology and applications and to design and develop real time OPAMP applications.	
UNIT – I	**IC FABRICATION AND REALIZATION**	**(9 Periods)**
IC Classification - fundamental of monolithic IC technology: epitaxial growth, masking and etching, diffusion of impurities - Realization of monolithic ICs and packaging - Fabrication of diodes, capacitance, resistance and FETs.		
UNIT – II	**OPERATIONAL AMPLIFIERS CHARACTERISTICS**	**(9 Periods)**
Functional block diagram - Ideal op-amp - Open loop and closed loop operation – CMRR- Input bias and offset currents - Input and output offset voltages – Compensation techniques - Frequency response of op-amp – Transfer characteristics - Slew rate - Bandwidth.		
UNIT – III	**APPLICATIONS OF OPERATIONAL AMPLIFIERS**	**(9 Periods)**
Inverting and Non Inverting amplifiers – Differential amplifiers - Instrumentation amplifiers - Integrator and differentiator - V/I & I/V converters - Active Filters – Voltage to frequency converters – Sample and Hold circuits – Comparators – Clippers – Clampers - Zero crossing detectors – Square and triangular waveform generator.		
UNIT – IV	**555 TIMERS, A/D AND D/A CONVERTERS**	**(9 Periods)**
555 timer – Functional block diagram - Astable and monostable operation of 555 timer – Applications – A/D converters (Flash and successive approximation types) - D/A converters (R- 2R ladder and weighted resistor types).		
UNIT – V	**APPLICATION ICs**	**(9 Periods)**
Positive and negative voltage regulators (IC723) Adjustable voltage regulators (LM117/LM317) – Dual tracking regulators (78xx & 79xx Series) – SMPS -Phase Locked loop (IC565)- Programmable supply – LM 380 power amplifier - ICL 8038 function generator IC.		
Contact Periods : **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*David A. Bell,* ***"Op-Amps and Linear Integrated Circuits"****, Oxford University Press, III Edition, 2012.*
2	*D. Roy Choudhury and Shail Jain,* ***"Linear Integrated Circuits",*** *New Age International, IV Edition, 2017.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the fabrication of semiconductor devices and circuits	K2
CO2	Analyze working of circuits in practical conditions	K4
CO3	Identification of suitable solutions to real time problems	K2
CO4	Application of circuits for interfacing and generation of waveforms	K3
CO5	Use of general-purpose circuits to specific applications and Utility of devices in regulated supply for electronic circuits	K3

REFERENCES:

1	*Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", Pearson Education, XI Edition, 2019.*
2	*Jacob Millman and Christos C. Halkias,* ***"Integrated Electronics: Analog and Digital Circuits and Systems"****, McGraw-Hill Education, II Edition, 2007.*
3	*Ramakant A. Gayakwad,* ***"Op-Amps and Linear Integrated Circuits"****, Prentice Hall of India, IV Edition, 2020.*
4	*Sergio Franco,* ***"Design with Operational Amplifiers and Analog Integrated Circuits",*** *McGraw-Hill, IV Edition, 2015.*
5	*Adel S. Sedra and Kenneth C. Smith,* ***"Microelectronic Circuits",*** *Oxford University Press, VII Edition, 2015.*

25WPE304	ELECTRICAL AND ELECTRONIC MEASUREMENTS	SEMESTER III

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the construction, operation and its importance of instruments in measurements and provide practical experience to supplement the theoretical knowledge gained in the field of measurements.	
UNIT – I	**MEASUREMENTS OF ELECTRICAL QUANTITIES AND ERROR ANALYSIS**	**(9 Periods)**
Functional elements of Instruments, -Standards and calibrations - Principle of operation of Permanent Magnet Moving Coil, Moving Iron, Dynamometer, induction, thermal and rectifier instruments - Extension of instrument ranges - Limiting errors of instruments - Combination of limiting errors – Gross, systematic and random errors in measurements - Statistical analysis of errors.		
UNIT – II	**MEASUREMENTS OF R, L AND C**	**(9 Periods)**
Wheatstone, Kelvin, Wein, Hay's, Maxwell, Anderson and Schering bridges - Q meter - Measurement of self and mutual inductances - Wagner earthing device – Earth Resistance Measurement.		
UNIT –III	**MEASUREMENTS OF MAGNETIC QUANTITIES AND INSTRUMENT TRANSFORMERS**	**(9 Periods)**
Flux meters – B-H curve and permeability measurements on ring and bar specimens – Iron loss - measurement by magnetic squares – Instrument transformers - types and errors - Instruments for measurement of frequency and power factor - maximum demand Indicator		
UNIT –IV	**ELECTRONIC INSTRUMENTATION**	**(9 Periods)**
Sensors and Transducers – Signal Conditioning - Digital voltmeter – Digital Multimeter – Digital Clamp meter - True RMS meter - Standard signal generators - Function generator - Spectrum analyzer - Power Quality analyzer- Introduction to virtual Instrumentation		
UNIT – V	**DISPLAY DEVICES AND RECORDERS**	**(9 Periods)**
Digital storage oscilloscope – Active and passive probes - Errors in measurement – calibration of probes - Seven segment display – LED, LCD - Concepts of Smart meter – Net metering - Data logger.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*A. K. Sawhney, **"A Course in Electrical and Electronic Measurements and Instrumentation"**, Dhanpat Rai & Sons, XIX Edition, 2015.*
2	*David A. Bell, **"Electronic Instrumentation and Measurements"**, Oxford University Press, III Edition, 2013.*

REFERENCES:

1	*J. B. Gupta, **"A Course in Electrical and Electronic Measurements"**, S. K. Kataria & Sons, X Edition, 2012 (Reprint 2021).*
2	*N. V. Suryanarayana and H. V. Shivanna, **"Electronic Instrumentation"**, McGraw-Hill Education, II Edition, 2018.*
3	*H. S. Kalsi, **"Electronic Instrumentation"**, McGraw-Hill Education, IV Edition, 2019.*
4	*Ernest O. Doebelin and Dhanesh N. Manik, **"Measurement Systems: Application and Design"**, McGraw-Hill Education, VI Edition, 2011 (Reprint 2017).*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the standards, characteristics and errors of measurements	K2
CO2	Demonstrate the operation of electrical and electronics measuring instruments	K3
CO3	Identify the kind of instrument for measurement of different quantities.	K3
CO4	Test and measure electrical and electronic parameters using instruments.	K4
CO5	Analyze and calculate all the parameters related to measurements.	K4

25WPE305	ELECTRICAL MACHINES LABORATORY	SEMESTER III

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To provide hands-on training for evaluating the performance and characteristics of DC and AC Machines and to identify the suitability of its applications.

LIST OF EXPERIMENTS:

1. Swinburne's test and Speed control of D.C. shunt motor.
2. Open circuit characteristics and load test on D.C. shunt generator.
3. Open circuit characteristics and load test on separately excited D.C. generator
4. Load test on D.C. shunt motor.
5. OC and SC tests on single phase transformers.
6. Load test on single phase transformer.
7. Sumpner's test.
8. Regulation of Alternator by EMF and MMF Methods.
9. Load test on three phase Alternator.
10. Regulation of Alternator by ZPF method.
11. V and Inverted V curves of Synchronous Motor.
12. Parallel operation of Alternators.
13. Equivalent Circuit of three phase Induction Motor.
14. Load Test on three phase Induction Motor.

Contact Periods:

Lecture: 0 Periods Tutorial:0 Periods Practical: 45 Periods Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Determine the performance characteristics of different types of AC and DC Machines.	K2
CO2	Suggest suitable test for performance determination of Rotating AC and DC Machines.	K3
CO3	Analyze and evaluate the performance of rotating machines.	K5
CO4	Identify suitable speed control methods for rotating machines.	K2
CO5	Evaluate the electrical apparatus to identify the suitability for different applications.	K5

25WPE401	CONTROL SYSTEMS ENGINEERING	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To understand the different ways of system representations, to assess the system dynamics and to design appropriate controllers and compensators.	
UNIT – I	**CONTROL SYSTEM MODELING**	**(9 Periods)**
Basic Elements of Control System - Open loop and Closed loop systems - Transfer function models of linear time - invariant systems - Modelling of Electric systems, Mechanical systems - Block diagram reduction Techniques - Signal flow graph.		
UNIT – II	**TIME DOMAIN ANALYSIS**	**(9 Periods)**
Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number. P, PI, PD, PID controllers.		
UNIT – III	**FREQUENCY DOMAIN ANALYSIS**	**(9 Periods)**
Relationship between time and frequency response, Bode plots, Polar plots, Nichols chart, Nyquist plot - gain and phase margin, Construction of M&N circles - Closed loop frequency response.		
UNIT-IV	**STABILITY ANALYSIS**	**(9 Periods)**
Concept of stability-Bounded – Input Bounded – Output stability-Routh stability criterion- Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.		
UNIT – V	**STATE SPACE ANALYSIS OF CONTINUOUS SYSTEMS**	**(9 Periods)**
Concepts of state variables - State space model – Decomposition of transfer function – Canonical state model – Transfer function from state model – Solution of state equations – State transition matrix –Eigen values - Eigen vectors - Concept of Controllability and Observability.		
Contact Periods: **Lecture:45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK :

1	Nagarath, I.J. and Gopal, M**.,** ***"Control Systems Engineering"*****,** New Age International Publishers, 2017.
2	S.K. Bhattacharya, ***"Control Systems Engineering"***, Sheffield Hallam University, 2017.

REFERENCES:

1	*Nise, Norman S., "**Control systems engineering**", Wiley, 2020.*
2	*B.C. Kuo & Farid Golnaraghi, "**Automatic Control System**", McGraw Hill, 2018.*
3	*S. Salivahanan, "**Control Systems Engineering**", Pearson, India, 2015.*
4	*Manke, B. S, "**Control System Design**", Mercury Learning & Information, 2017.*
5	*K. Ogata, "**Modern Control Engineering**", 5th edition, PHI, 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	**Model** linear-time-invariant systems using transfer function and state space forms.	K3
CO2	**Compare** various feedback control strategies.	K2
CO3	**Analyze** the system stability in frequency domain.	K4
CO4	**Analyze** the system stability in Time domain	K5
CO5	**Evaluate** the system stability using the state space model.	K5

25WPE402	POWER SYSTEM ANALYSIS	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To model and analyze the electric power network under normal and abnormal operating conditions for the design of protective and control apparatuses through the analysis results	
UNIT – I	**POWER SYSTEM MODELLING**	**(9 Periods)**
Basic components of a power system – Single line diagram – Per unit representation: Generator, Transformer, Transmission line and load representation - Primitive network – Construction of Y-bus using inspection and singular transformation methods.		
UNIT – II	**POWER FLOW ANALYSIS**	**(9 Periods)**
Importance of power flow analysis – Classification of buses – Development of power flow model in complex variables form – Iterative solution using Gauss-Seidel method, Newton - Raphson method and Fast Decoupled Method.		
UNIT – III	**ANALYSIS OF BALANCED FAULTS**	**(9 Periods)**
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	**ANALYSIS OF UNBALANCED FAULTS**	**(9 Periods)**
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.		
UNIT – V	**STABILITY ANALYSIS**	**(9 Periods)**
Importance of stability analysis – Classification of power system stability – Rotor angle and voltage stability – Single Machine Infinite Bus System: Swing Equation – Equal area criterion – Determination of critical clearing angle and time – Solution of swing equation by Modified Euler method and fourth order Runge - Kutta method.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*I. J. Nagrath and D. P. Kothari, **"Modern Power System Analysis"**, McGraw-Hill Education, IV Edition, 2022.*
2	*P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, **"Electrical Power Systems: Analysis, Security and Deregulation"**, PHI Learning, II Edition, 2017.*

REFERENCES:

1	*D. P. Kothari, I. J. Nagrath and R. K. Saket,* ***"Modern Power System Analysis"****, McGraw-Hill Education, V Edition, 2022.*
2	*C. L. Wadhwa,* ***"Electrical Power Systems"****, New Age International, VIII Edition, 2022.*
3	*Hadi Saadat,* ***"Power System Analysis"****, PSA Publishing, III Edition, 2010.*
4	*John J. Grainger and William D. Stevenson Jr.,* ***"Power System Analysis"****, McGraw-Hill Education, II Edition, 2016.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Model the power system under steady state operating conditions.	K6
CO2	Illustrate numerical methods to solve the power flow problem.	K2
CO3	Analyze the system under fault conditions.	K4
CO4	Examine the transient behavior of the power system under fault conditions.	K4
CO5	Evaluate the power system network for stable operation.	K5

25WPE403	POWER ELECTRONICS	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn about the operation of different types of power semiconductor devices and circuits and identify the more efficient circuit for specific applications.	
UNIT – I	**POWER SEMICONDUCTOR DEVICES**	**(9 Periods)**
Basic structure and switching characteristics of Power diode - Power transistor - SCR- Ratings of SCR - Series Parallel operation of SCR - di/dt and dv/dt protection - TRIAC – GTO - MOSFET and IGBT - Gate driving circuits.		
UNIT –II	**CONTROLLED RECTIFIERS**	**(9 Periods)**
Operation and analysis of 1Φ half and fully controlled rectifiers with R, RL and RLE loads - Operation of 3Φ Half and Fully controlled Rectifier with R and RL loads - Effect of source impedance - 1Φ and 3Φ Dual Converters.		
UNIT – III	**DC – DC CONVERTER**	**(9 Periods)**
Buck, Boost and Buck – Boost Converters – Control Strategies - Classification and operation of different types of choppers – Forced commutation: Operation of voltage, current and load commutated choppers - SMPS.		
UNIT – IV	**INVERTERS**	**(9 Periods)**
Types of inverters - Operation of 1Φ - 3Φ bridge inverters (120 and 180 degree modes) – Current Source Inverter - 1Φ ASCSI - Voltage Source Inverter - 1Φ and 3Φ PWM inverters – types of PWM (single pulse, multiple pulse and sine PWM) - Modulation Index-Fourier analysis of PWM inverter output voltage.		
UNIT – V	**AC VOLTAGE CONTROLLERS**	**(9 Periods)**
Types of control: Phase and Integrated cycle - Operation of 1Φ voltage regulator with R- RL loads - Operation of 3Φ AC voltage controller with R load - 1Φ step up and step down cyclo converters.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Muhammad H. Rashid, **"Power Electronics: Circuits, Devices and Applications"**, Pearson Education (India), IV Edition, 2014.*
2	*P. S. Bimbhra, **"Power Electronics"**, Khanna Publishers, VII Edition, 2022.*

REFERENCES :

1	*John G. Kassakian, David J. Perreault, George C. Verghese and Martin F. Schlecht, **"Principles of Power Electronics"**, Cambridge University Press, II Edition, 2024.*
2	*M. D. Singh and K. B. Khanchandani, **"Power Electronics"**, McGraw-Hill Education, II Edition, 2007.*
3	*Ned Mohan, Tore M. Undeland and William P. Robbins, **"Power Electronics: Converters, Applications and Design"**, Wiley India, III Edition, 2022.*
4	*G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, **"Thyristorised Power Controllers"**, New Age International, II Edition, 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about fundamental concepts and techniques used in power electronics.	K2
CO2	Illustrate and compare performance of various power semiconductor devices and switching circuits	K3
CO3	Demonstrate the operation of power electronic converters.	K2
CO4	Select suitable devices by assessing the circuits for various applications.	K4
CO5	Analyze and evaluate the performance of a power electronic circuit.	K5

25WPE404	POWER SYSTEMS AND POWER ELECTRONICS LABORATORY	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To understand power system calculations and to gain practical experience on power electronic converters.	
	LIST OF EXPERIMENTS:	**No. of periods :45**

1. Computation of Parameters and Modeling of Transmission Lines
2. Transmission Line Performance
3. Formation of Bus Admittance and Impedance Matrices
4. Load Flow Analysis Using Gauss-Seidel and Newton Raphson Methods
5. Symmetrical and Unsymmetrical Fault Analysis
6. Transient and Small Signal Stability Analysis: Single-Machine Infinite Bus System
7. Single phase half-controlled rectifier
8. Single phase fully controlled bridge rectifier
9. Buck, Boost and Buck-Boost converters
10. Single phase inverter
11. Single phase voltage control using SCR and TRIAC
12. Simulation of Three Phase inverter.

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate the Power System Analysis, Control, Operation and Protection problems virtually through simulation and hardware setup.	K2
CO2	Apply the concepts described in various power system theories to actual situations.	K3
CO3	Analyze ideas learnt through various power system concepts in designing and planning a new one.	K4
CO4	Evaluate the existing power system for its reliable operation.	K5
CO5	Propose modern technologies for the enhanced operation of power systems.	K6

25WPE501	POWER SYSTEM OPERATION AND CONTROL	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	The course aims to equip students with fundamental and advanced concepts in power system operation and control, covering load characteristics, frequency and voltage regulation, economic dispatch, unit commitment, and computer-based real-time system management.	
UNIT – I	**OVERVIEW TO POWER SYSTEM OPERATION AND CONTROL**	**(9 Periods)**
System load variation: System load characteristics, load curves - daily, weekly and annual, load-duration curve, load factor, diversity factor - Reserve requirements. Necessity for voltage and frequency regulation of power system - P-f and Q-V control loops – recent trends in real time control of power system – Introduction to load dispatching, load forecasting, unit commitment, load shedding and islanding.		
UNIT – II	**FREQUENCY CONTROL**	**(9 Periods)**
Plant and system level control – mathematical model of speed governing system – speed load characteristics – regulation of two generators in parallel – concept of control area – LFC control of a single area system – static and dynamic response of uncontrolled and controlled system - LFC of two area system – static and dynamic response of uncontrolled system – tie line with frequency bias control of two area system.		
UNIT – III	**VOLTAGE CONTROL**	**(9 Periods)**
Type of excitation system – Characteristics of excitation system – block diagram of excitation system - static and dynamic analysis. Reactive power control – Automatic voltage regulator, Methods of voltage control: OLTC, synchronous condenser, SVC, shunt capacitor – Power system level voltage control using tap changing transformer.		
UNIT – IV	**ECONOMIC DISPATCH AND UNIT COMMITMENT**	**(9 Periods)**
Incremental cost curve – co-ordination equation without loss – solution by Lambda iteration method – co-ordination equation with loss – solution of co-ordination equation using B_{mn} coefficients – base point and participating factors. Unit commitment: problem and its constraints – Solution by Priority list method, Economic dispatch controller added to load frequency control.		
UNIT – V	**DIGITAL POWER SYSTEM CONTROL AND MONITORING**	**(9 Periods)**
Energy control center: National, Regional and State Level – SCADA system – configuration – function – monitoring, data acquisition and controls – EM system – System operating states: Normal, alert, emergency, restorative – control strategies - IEC and IEEE standards for communication and interoperability.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Abhijit Chakrabarti and Sunita Halder,* ***"Power System Analysis: Operation and Control"****, PHI Learning Private Limited, IV Edition, 2022.*
2	*Robert H. Miller and James H. Malinowski,* ***"Power System Operation"****, McGraw-Hill Education, III Edition, 1994.*

REFERENCES:

1	*D. P. Kothari, I. J. Nagrath and R. K. Saket,* ***"Modern Power System Analysis"****, McGraw-Hill Education, V Edition, 2022.*
2	*P. Kundur and O. P. Malik,* ***"Power System Stability and Control"****, McGraw-Hill Education, II Edition, 2022.*
3	*Allen J. Wood, Bruce F. Wollenberg and Gerald B. Sheblé,* ***"Power Generation, Operation and Control"****, Wiley-Interscience, III Edition, 2014.*
4	*P. S. R. Murty,* ***"Operation and Control in Power Systems"****, BS Publications, II Edition, 2011.*
5	*O. I. Elgerd,* ***"Electric Energy Systems Theory: An Introduction"****, McGraw-Hill Education, II Edition, 1982.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the characteristics of system load variations and explain the necessity for voltage and frequency regulation in power systems.	K4
CO2	Develop and evaluate models for load frequency control in single and multi-area systems under dynamic operating conditions.	K5
CO3	Examine excitation systems and apply appropriate voltage control methods to maintain power system stability.	K3
CO4	Apply optimization techniques for economic load dispatch and solve unit commitment problems considering operational constraints.	K3
CO5	Demonstrate the use of SCADA and EMS systems for real-time monitoring and control of power systems in compliance with relevant standards.	K2

25WPE502	POWER SYSTEM PROTECTION	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	Achieve mastery in the principles and applications of protective relays, including types, components, construction, operational principles, protection schemes, and performance considerations.	
UNIT – I	**PROTECTIVE RELAYS**	**(9 Periods)**
Electromagnetic relays – Basic requirements of relays – Primary and backup protection – Attracted armature, Balanced beam, Inductor type and differential relays – Universal torque equation – Characteristics of over current, Direction and distance relays – Definite time, Inverse and IDMT relays.		
UNIT – II	**PROTECTION OF GENERATORS AND TRANSFORMERS**	**(9 Periods)**
Protection of generators against stator faults, Rotor faults and abnormal conditions - Restricted earth fault and inter-turn fault protection, Numerical problems on percentage winding unprotected. Protection of transformers: Percentage differential protection, Calculation of CT Ratio, Buchholz relay protection.		
UNIT – III	**PROTECTION OF TRANSMISSION LINE AND BUSBAR**	**(9 Periods)**
Protection of feeder - Radial and ring main using over current relays - Protection of transmission line – Three-zone protection using distance relays - Carrier current protection - Protection of bus bars.		
UNIT – IV	**CIRCUIT BREAKERS**	**(9 Periods)**
Elementary principles of arc interruption, Recovery – Restriking phenomenon, RRRV – Current chopping and resistance switching – CB ratings, specifications and Types – Auto reclosure. Description and operation of Minimum oil, Air blast, Vacuum and SF_6 circuit breakers.		
UNIT – V	**OVERVOLTAGE PROTECTION IN POWER SYSTEMS**	**(9 Periods)**
Protection against lightning over - voltages – Valve type and Zinc-Oxide lightning arresters – Insulation coordination – Basic Insulation Level – Switching Impulse Level.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Badri Ram, D. N. Vishwakarma and Soumya R. Mohanty,* ***"Power System Protection and Switchgear"****, McGraw-Hill Education, III Edition, 2022.*
2	*Y. G. Paithankar and S. R. Bhide,* ***"Fundamentals of Power System Protection"****, PHI Learning Private Limited, II Edition, 2010.*

REFERENCES:

1	*Bhavesh Bhalja, R. P. Maheshwari and Nilesh G. Chothani,* ***"Protection and Switchgear"****, Oxford University Press, II Edition, 2018.*
2	*A. S. Ingole,* ***"Switchgear and Protection"****, Umesh Publications, II Edition, 2018.*
3	*B. Ravindranath and M. Chander,* ***"Power System Protection and Switchgear"****, New Age International Publishers, II Edition, 2011.*
4	*C. Christopoulos and A. Wright,* ***"Electrical Power System Protection"****, Springer, II Edition, 1999.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Discuss the performance of protective relays, components of protection schemes and relay terminology	K2
CO2	Illustrate various protection schemes, construction, operating principle for the protection of power system apparatuses like generators, motors, transformer and bus bar.	K2
CO3	Examine the construction, working of distance relays, the effects of various parameters on the performance of distance relays.	K4
CO4	Summarize the construction and operation of different types of circuit breakers and compare their performances against requirements.	K2
CO5	Analyze causes of overvoltage and evaluate its protection schemes	K5

25WPE503	HVDC TRANSMISSION SYSTEM	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To familiarize with the HVDC transmission system and its control	
UNIT – I	**GENERAL ASPECTS OF HVDC SYSTEM**	**(9 Periods)**
AC and DC transmission systems – Structure and Comparison, Types of DC links, DC cables and line insulators – Recent Trends in HVDC - Components of a HVDC system – Applications.		
UNIT – II	**CONVERTER CIRCUITS AND ANALYSIS**	**(9 Periods)**
Three Phase bridge converter using SCRs - Operating principle - Waveforms - Gate control and overlap – Voltage, current and power factor – Commutating resistance – Inversion – Equivalent circuit – Analysis and charts for overlap less than 60^{o} only.		
UNIT – III	**CONVERTER CONTROL**	**(9 Periods)**
Concept of control – Control characteristics – Constant minimum firing angle control – Constant current control – Constant extinction angle control – Tap changer control – Power and frequency control – Stability – Starting and stopping of DC link.		
UNIT – IV	**FAULTS AND PROTECTION**	**(9 Periods)**
Bypass valve – SCR valves malfunctions – Over voltage and current oscillations – DC circuit breakers – DC lightning arrestors.		
UNIT – V	**HARMONICS, FILTERS AND GROUND RETURN**	**(9 Periods)**
Characteristic and uncharacteristic harmonics – Harmonic AC and DC filters – Interference with communication systems – Ground return – land, shore and sea electrodes – Cathodic protection – DC corona.		
Contact Period: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*K. R. Padiyar,* ***"HVDC Power Transmission Systems"****, New Age International Publishers, III Edition, 2017.*
2	***Dragan Jovcic and Khaled Ahmed, "High Voltage Direct Current Transmission: Converters, Systems and DC Grids"****, Wiley, II Edition, 2019.*

REFERENCES:

	C. L. Wadhwa, ***"Electrical Power Systems"****, New Age International Publishers, VIII Edition, 2022.*
2	*V. K. Sood,* ***"HVDC and FACTS Controllers: Applications of Static Converters in Power Systems"****, Springer, I Edition, 2004.*
3	*J. Arrillaga,* ***"High Voltage Direct Current Transmission"****, Institution of Engineering and Technology (IET), II Edition, 1998.*
4	*C. Adamson and N. G. Hingorani,* ***"High Voltage Direct Current Power Transmission"****, Garraway Limited, I Edition, 1960.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze HVDC system and enumerate its merits	K4
CO2	Appraise and analyze different converter circuits	K4
CO3	Apply converter control for power flow	K3
CO4	Select suitable protection method for various converter faults	K2
CO5	Illustrate about harmonic filtering in HVDC systems	K3

25WPE504	MICROPROCESSOR AND MICROCONTROLLER PROGRAMMING	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the basic concepts of microprocessor and microcontroller hardware and assembly language programming and to demonstrate interfacing techniques and applications.	
UNIT – I	**8085 ARCHITECTURE**	**(9 Periods)**
Architecture and Addressing modes of 8085 processors - Instruction set of 8085 - Assembly language programming – Introduction to Microcontrollers		
UNIT – II	**PIC18 MICROCONTROLLER FRAMEWORK**	**(9 Periods)**
Architecture - Instruction set - Memory organizations - Register file structure - CPU registers - Addressing modes - Assembly language programming.		
UNIT – III	**REAL TIME CONTROL**	**(9 Periods)**
Timers – Prescaler and generating a large time delay- Timer 0,1,2,3 and Counter programming – PWM Generation - Interrupts-Interrupt Service Routine-Sources of interrupts – Programming timer interrupts, external hardware interrupts, serial communication interrupt – Interrupt priority.		
UNIT – IV	**PERIPHERALS OF PIC MICROCONTROLLER**	**(9 Periods)**
ADC programming in PIC – DAC interfacing – Sensor interfacing and signal conditioning – Basics of serial communication – PIC connection to RS232 – Serial port programming		
UNIT – V	**MICROCONTROLLER APPLICATIONS**	**(9 Periods)**
LEDs, push buttons, relays and latch connection - Keyboard interfacing-interfacing 7 segment displays – LCD interfacing - Measurement, Automation and control applications.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*Muhammad Ali Mazidi, Rolin D. McKinlay and Danny Causey, **"PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18"**, Pearson Education, II Edition, 2008.*
2	*Ramesh S. Gaonkar, **"Microprocessor Architecture, Programming and Applications with the 8085"**, Penram International Publishing, V Edition, 2002.*

REFERENCES :

1	*Santanu Chattopadhyay,* ***"Microprocessors and Microcontrollers"****, McGraw-Hill Education,* ***I Edition, 2024****.*
2	*Douglas V. Hall,* ***"Microprocessors and Interfacing: Programming and Hardware"****, McGraw-Hill Education, II Edition, 2006.*
3	*A. K. Ray and K. M. Bhurchandi,* ***"Advanced Microprocessors and Peripherals"****, McGraw-Hill Education, II Edition, 2006.*
4	*John B. Peatman,* ***"Embedded Design with the PIC18F452 Microcontroller",*** *Prentice Hall, 2003.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explore the architecture of 8085, ARM and PIC microcontrollers.	K2
CO2	Illustrate the File Registers, Memory and employ assembly language programming	K2
CO3	Create interface between digital system and input/output devices	K2
CO4	Design and develop microcontroller based real-time applications	K3
CO5	Design and Develop skill in simple program writing for 8085, ARM and PIC microcontroller-based control applications	K3

25WPE601	PROJECT MANAGEMENT AND ENTREPRENEURSHIP	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To introduce the management, societal and financial aspects of Entrepreneurship.	
UNIT – I	**ENTREPRENEURSHIP**	**(9 Periods)**
Need, scope, Entrepreneurial competencies & traits, Factors affecting entrepreneurial development, Entrepreneurial motivation (Mc Clellend's Achievement motivation theory), conceptual model of entrepreneurship, entrepreneur vs. intrapreneur; Classification of entrepreneurs, Entrepreneurial Development Programmes.		
UNIT – II	**ENTREPRENEURIAL IDEA AND INNOVATION**	**(9 Periods)**
Introduction to Innovation, Entrepreneurial Idea Generation and Identifying Business Opportunities, Management skills for Entrepreneurs and managing for Value Creation, Creating and Sustaining Enterprising Model & Organizational Effectiveness		
UNIT – III	**SOCIAL ENTREPRENEURSHIP**	**(9 Periods)**
Social Sector Perspectives and Social Entrepreneurship, Social Entrepreneurship Opportunities and Successful Models, Social Innovations and Sustainability, Marketing Management for Social Ventures.		
UNIT – IV	**PROJECT MANAGEMENT**	**(9 Periods)**
Project life-cycle, Project Identification and Screening – SWOT Analysis, Project appraisal – Market, Technical, Economic, Environmental and Financial (Pay Back, Net Present value, Internal Rate of Return), Sources of Project Finance – Debt Financing, Equity Financing, Grants, Venture Capital, Crowd Funding.		
UNIT – V	**ORGANIZATIONAL / BEHAVIOURAL ASPECTS OF PROJECT MANAGEMENT**	**(9 Periods)**
Organization Structure – Departmentalization, Types of organizational designs – Group Behaviour – Stages of group development, group decision making – Understanding work teams.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Saurabh Bajpai and Shubhendu Shekhar Shukla,* ***"Project Management and Entrepreneurship"****, S. K. Kataria & Sons, I Edition, 2024.*
2	*Salahuddin Ansari, Mohammad Imtiaz and Jaya Jain,* ***"Entrepreneurship and Project Management"****, Book Rivers Publishers, I Edition, 2023.*

REFERENCES:

1	*Stephen P. Robbins, Timothy A. Judge and Neharika Vohra,* ***"Organizational Behaviour"****, Pearson Education India, XVIII Edition, 2022.*
2	*P. Gopalakrishnan and V. E. Ramamoorthy,* ***"Textbook of Project Management"****, Laxmi Publications, I Edition, 2022.*
3	*John M. Nicholas and Herman Steyn,* ***"Project Management for Engineering, Business and Technology"****, Routledge, VI Edition, 2021.*
4	*Rajeev Roy,* ***"Entrepreneurship"****, Oxford University Press India, III Edition, 2020.*
5	*Lipika K. Guilani and R. K. Gupta,* ***"Fundamentals of Entrepreneurship Development and Project Management"****, Himalaya Publishing House, I Edition, 2017.*

COURSE OUTCOMES: **On completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Explain the factors affecting entrepreneurial development and classify the types of Entrepreneurs.	**K2**
CO2	Apply innovative ideas in Entrepreneurship	**K3**
CO3	Explain impact of social, environmental and legal factors on Entrepreneurship	**K2**
CO4	Prepare project proposal considering various factors	**K3**
CO5	Apply suitable Organizational / Behavioural concepts in Project management	**K3**

25WPE602	INDUSTRIAL DRIVES AND CONTROL	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the concepts of electrical drives and their applications in carrying out modern industrial processes and to expose modern drives for energy conservation.	
UNIT – I	**SPEED CONTROL OF DC MOTORS**	**(9 Periods)**
Concept of Electric Drive: Classification, Torque calculation, sizing of motor, Types of load torque, Speed/Torque characteristics – Types of Duty - Heating and cooling curves - Braking methods – Ward Leonard Method - Control of Drives with Semi and Full converters– Quadrants of operation - Dual converter fed DC drives.		
UNIT – II	**DIGITAL CONTROL OF DC MOTORS**	**(9 Periods)**
Digital technique in speed control of DC motors – Comparison between Analog and Digital Control – Closed loop control of DC drives –Inner Current Loop and Outer Speed Loop – control of DC motor using microprocessor – Speed, Voltage and current Sensing Techniques.		
UNIT – III	**SPEED CONTROL OF AC MOTORS**	**(9 Periods)**
Speed control of AC motors – Speed / Torque characteristics – Regenerative Braking - AC Voltage controller fed drives, PWM Inverter fed drives, Stator Voltage, Frequency and V/f control of induction motors - Self, Margin angle and power factor control of Synchronous Motors.		
UNIT – IV	**ROTOR SIDE CONTROL OF INDUCTION MOTOR**	**(9 Periods)**
Static control of Rotor resistance – Speed Control Using Rotor Injected EMF: Slip-Energy recovery scheme, Static Scherbius and Kramer systems – Speed control using microprocessor.		
UNIT – V	**INDUSTRIAL APPLICATIONS**	**(9 Periods)**
Choice of selection of motors – Electric drive applications: Steel rolling mills – Cement mills – Paper mills – Textile mills – Sugar mills – Coal mines – Machine Tools - E mobility - Robotics.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

	*P. C. Sen, **"Principles of Electric Machines"**, Wiley India, III Edition, 2020.*
2	*G. K. Dubey, **"Fundamentals of Electrical Drives"**, Narosa Publishing House, II Edition, 2001.*

REFERENCES :

1	*Vedam Subramanyam, **"Electrical Drives and Applications"**, McGraw-Hill Education, II Edition, 2017.*
2	*S. K. Pillai, **"A First Course on Electrical Drives"**, New Age International Publishers, III Edition, 2012.*
3	*R. Krishnan, **"Electric Motor Drives: Modeling, Analysis and Control"**, Prentice Hall India, I Edition, 2001.*
4	*Nouira, **"Control Strategies of Electric Drives"**, Springer, I Edition, 2023.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Illustrate the role of power electronics in modern drives.	K2
CO2	Design the digital controller for drives.	K4
CO3	Demonstrate the speed control techniques for AC drives	K3
CO4	Categorize drive for particular applications considering the present and future needs of industries.	K4
CO5	Apply microprocessors in control of electric drives	K3

25WPE603	ELECTRICAL MACHINE DESIGN	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To impart knowledge on designing static and Rotating machines based upon fundamental theories.	
UNIT – I	**FUNDAMENTALS OF ELECTRICAL MACHINE DESIGN**	**(9 Periods)**
Major considerations in Electrical Machine Design - Electrical Engineering Materials - Space factor - Choice of Specific Electrical and Magnetic loadings- Concept of magnetic circuit-MMF calculation for various types of electrical machines - Thermal considerations - Heat flow - Temperature rise and Insulating Materials - Rating of machines - IE3, IE4, NEMA Standards.		
UNIT – II	**DESIGN OF DC MACHINES**	**(9 Periods)**
Output Equation - Main Dimensions - Choice of Specific Electric and Magnetic Loading - Magnetic Circuits Calculations - Carter's Coefficient - Net length of Iron - Selection of number of poles - Design of Armature, commutator, air gap, field poles, field coil and brushes.		
UNIT – III	**DESIGN OF TRANSFORMERS**	**(9 Periods)**
Output Equation - Main Dimensions - kVA rating for single and three phase transformers - Window space factor - Design of core, yoke and winding - Overall dimensions - Operating characteristics - No load current - Temperature rise - Design of Tank and cooling tubes.		
UNIT – IV	**DESIGN OF INDUCTION MOTORS**	**(9 Periods)**
Output equation of Induction motor - Main dimensions - Design of stator - Choice of Average flux density- Length of air gap- Rules for selecting rotor slots of squirrel cage machines-Design of rotor bars, slots and end rings - Design of wound rotor - Magnetic leakage calculations - Leakage reactance of poly phase machines - Magnetizing current - Short circuit current - Operating characteristics - Losses and Efficiency.		
UNIT – V	**DESIGN OF SYNCHRONOUS MACHINES**	**(9 Periods)**
Output equations - Choice of Electrical and Magnetic Loading - Design of salient pole machines - Short circuit ratio - Shape of pole face - Armature design - Estimation of air gap length - Design of rotor and damper winding - Determination of full load field MMF – Design of field winding - Design of turbo alternators - Rotor design.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*A. K. Sawhney and A. Chakrabarti, **"A Course in Electrical Machine Design"**, Dhanpat Rai & Co. Pvt. Ltd., VI Edition, 2015.*
2	*Juha Pyrhönen, Tapani Jokinen and Valéria Hrabovcová, **"Design of Rotating Electrical Machines"**, John Wiley & Sons, II Edition, 2013.*

REFERENCES:

	V. Rajini and V. S. Nagarajan, ***"Electrical Machine Design"****, Pearson Education, I Edition, 2018.*
2	*Thomas A. Lipo,* ***"Introduction to AC Machine Design"****, Wiley-IEEE Press, I Edition, 2017.*
3	*K. M. Vishnu Murthy,* ***"Computer Aided Design of Electrical Machines"****, BS Publications, I Edition, 2015.*
4	***V. N. Mittle and A. Mittal,*** *"****Design of Electrical Machines"****,* ***5th Edition,*** *Standard Publishers Distributors,* ***2002****.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Illustrate the basics of design considerations for rotating and static electrical machines.	K2
CO2	Design DC machines as per requirements.	K3
CO3	Create Transformers as per requirements.	K2
CO4	Develop Induction machines as per requirements.	K5
CO5	Formulate and analyze synchronous machines.	K4

25WPE604	RENEWABLE ENERGY SOURCES	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To elucidate the technologies used for generation of power from renewable energy resources.	
UNIT – I	**RENEWABLE ENERGY SOURCES**	**(9 Periods)**
Conventional energy sources - Environmental consequences - Renewable energy sources - Types of RE sources - Limitations - Present Indian and International scenario of Conventional and RE sources and policies, Overview of micro and mini hydel power generation.		
UNIT – II	**SOLAR ENERGY AND THERMAL ENERGY**	**(9 Periods)**
Solar Radiation, Radiation Measurement: solar spectra-latitude and longitude, Declination angle, solar window, cosine law, seasonal variations, hour angle, calculation of angle of incidence, angstroms equation and constants - Solar Photovoltaic systems: Cell, Types, module, array – IV/PV Characteristics, Efficiency - series and parallel connections, maximum power point tracking, Applications. Solar Thermal Power Plant: Central Receiver Power Plants, Solar Ponds - Thermal Energy storage system.		
UNIT – III	**WIND ENERGY**	**(9 Periods)**
Wind energy - Power in the Wind, wind data and energy estimation, site selection - wind energy conversion system: components, Types - horizontal and Vertical axes, Generators, Grid integration issues, applications.		
UNIT – IV	**BIOMASS ENERGY AND FUEL CELLS**	**(9 Periods)**
Biomass, sources of biomass, thermo-chemical and bio-chemical conversion of biomass - Pyrolysis, gasification, combustion and fermentation. Gasifiers – Up draft, downdraft and fluidized bed gasifier. Digesters- Fixed and floating digester biogas plants- Hydrogen Production and Storage- Fuel cell : Principle of working- various types - construction and applications, Hybrid Energy Systems.		
UNIT – V	**OCEAN AND GEOTHERMAL ENERGY**	**(9 Periods)**
Ocean energy resources - Principles of ocean thermal energy conversion systems - ocean thermal power plants - Principles of ocean wave energy conversion and tidal energy conversion - Difference between tidal and wave power generation, Economics of OTEC. Definition and classification of Geothermal resources, Utilization for electricity generation and direct heating, Wellhead power generating units.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*D. P. Kothari, K. C. Singal and Rakesh Ranjan,* ***"Renewable Energy Sources and Emerging Technologies"****, PHI Learning Private Limited, III Edition, 2022.*
2	*Chetan Singh Solanki,* ***"Solar Photovoltaics: Fundamentals, Technologies and Applications"****, PHI Learning Private Limited, II Edition, 2015.*

REFERENCES:

	G. D. Rai, ***"Non-Conventional Sources of Energy"****, Khanna Publishers, VI Edition, 2017.*
2	*Sunil S. Rao and B. B. Parulekar,* ***"Energy Technology"****, Khanna Publishers, III Edition, 2014.*
3	*S. N. Singh,* ***"Non-Conventional Energy Resources"****, Pearson Education India, I Edition, 2015*
4	*Roland Wengenmayr and Thomas Buhrke,* ***"Renewable Energy: Sustainable Energy Concepts for the Future"****, Wiley-VCH, II Edition, 2013.*
5	*Godfrey Boyle,* ***"Renewable Energy: Power for a Sustainable Future"****, Oxford University Press, III Edition, 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Interpret the impact and current scenario of renewable energy sources	K2
CO2	Explain the principles and applications of solar and thermal energy technologies	K3
CO3	Describe the principle, types and grid integration of wind energy technology	K3
CO4	Outline the characteristics, types and applications of biomass energy	K2
CO5	Acquire knowledge of the ocean and the geothermal technology	K2

25WPE701	ELECTRIC VEHICLE TECHNOLOGY	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	Understand electric propulsion unit configuration, integrate vehicle dynamics into design, explore EV battery usage, study electrical machines/controllers, and analyze EV energy management.	
UNIT – I	**OVERVIEW OF ELECTRIC VEHICLES**	**(9 Periods)**
Electric Vehicle Introduction, The Drive Torque, Power, Speed and Energy, Energy Source, Vehicle Auxiliary, Petrol pumps and Charging stations, Introduction to Electric Vehicles in India. Vehicle Subsystems: EV Power-train, Storage for EVs, Fundamentals of EV Battery Pack design, EV Motors and Controllers: Fundamentals and Design, Vehicle Accessories.		
UNIT – II	**VEHICLE DYNAMICS**	**(9 Periods)**
Forces acting when a vehicle move, Aerodynamic drag, Rolling Resistance and Uphill Resistance, Power and torque to accelerate, Concept of drive cycle, Drive Cycles and Energy used per km.		
UNIT – III	**MOTORS AND CONTROLLERS**	**(9 Periods)**
Induction Motor, BLDC, PMSM, SRM – Principle and Characteristics, Suitability Analysis, Control of Motors, Field-oriented Control, DC - DC and DC- AC Power Converters.		
UNIT – IV	**BATTERIES FOR EV AND EV CHARGER**	**(9 Periods)**
Battery Parameters, Types, Li-Ion Battery Cells, SoH and SoC estimation and Self-Discharge, Computation of Effective cost of battery. Charger Parameters, Types - Slow, Fast chargers and Swapping, Swapping - Standardization and on-board chargers, Public chargers, Public charger economics in Indian Context, Swapping stations and data analytics, IEC Standards for Chargers. BMS Design and Embedded System, Cell Testing & Characterization.		
UNIT – V	**HYBRID ELECTRIC VEHICLES (HEV)**	**(9 Periods)**
Classification - Series and Parallel HEVs-Advantages & disadvantages – Series - Parallel Combination - Internal Combustion Engines: Reciprocating Engines- Gas Turbine Engine- Design of an HEV: Hybrid Drive train - Sizing of Components.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*I. Husain, **"Electric and Hybrid Vehicles: Design Fundamentals"**, CRC Press, III Edition, 2021.*
2	*Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, **"Modern Electric, Hybrid Electric and Fuel Cell Vehicles"**, CRC Press, III Edition, 2018.*

REFERENCES

1	*Tariq Muneer and Irene Illescas García,* ***"Electric Vehicles: Prospects and Challenges"****, Elsevier, I Edition, 2017.*
2	***Nil Patel, Akash Kumar Bhoi, and Sanjeevikumar Padmanaban (Eds.),*** **"***Electric Vehicles: Modern Technologies and Trends", Springer, 2021.*
3	*Sheldon S. Williamson,* ***"Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles"****, Springer, I Edition, 2013.*
4	*James Larminie and John Lowry,* ***"Electric Vehicle Technology Explained"****, Wiley, II Edition, 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Comprehend the Electrical Vehicle configuration	K2
CO2	Identify the electric vehicle components to develop updated technologies	K3
CO3	Analyze the components for the performance improvements of complete EV System	K4
CO4	Design suitable drives and control for the operation of EV by applying concepts studied	K4
CO5	Evaluate the Vehicle performance in terms of vehicle dynamics, loss & economic considerations	K5

25WPE702	PROJECT WORK	SEMESTER VII

PREREQUISITES :	CATEGORY	L	T	P	C
NIL	PC	0	0	16	8

Course Objectives	1. To apply the theoretical knowledge acquired throughout the courses of Electrical and Electronics Engineering Programme to a project involving in real time. 2. To develop new algorithm / design / develop Fabrication in a novel way.

Project topic must be selected either from research literature or through innovative ideas to solve engineering problems in consultation with the guide.
The type of project can be Experimental work / prototype development / fabrication / feasibility studies / simulation / development of software.
A report on the project work done must be submitted at the end of the semester.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 240 Periods Total: 240 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply engineering principles, modern tools, and emerging technologies to design and implement a project in the form of a prototype, experimental setup, simulation, software, or fabrication.	K3
CO2	Analyze engineering problems through literature review and identify appropriate methodologies for developing innovative solutions.	K4
CO3	Evaluate the performance and feasibility of the developed solution using appropriate testing, analysis, validation, and optimization techniques.	K5
CO4	Defend to present and communicate the outcomes of the project.	K3
CO5	Work as a team and solve the given engineering problem and prepare a report.	K3

ELECTIVE – I

25WPE4E1	POWER QUALITY ENGINEERING	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To analyze the power quality issues in power systems and provide practical engineering solutions to mitigate the PQ problems	
UNIT – I	**INTRODUCTION TO POWER QUALITY PROBLEM**	**(9 Periods)**
Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.		
UNIT – II	**ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM**	**(9 Periods)**
Single phase linear and non-linear loads – single phase sinusoidal, non-sinusoidal source - supplying linear and nonlinear loads – three phase balanced system – three phase unbalanced system – three phase unbalanced and distorted source supplying nonlinear loads – concept of power factor – three phase- three wire – three phase - four wire system.		
UNIT – III	**MITIGATION OF POWER SYSTEM HARMONICS**	**(9 Periods)**
Introduction - Principle of Harmonic Filters – Series-Tuned Filters – Double Band-Pass Filters – damped Filters – Detuned Filters – Active Filters – Power Converters – Harmonic Filter Design – Tuned Filter – Second-Order Damped Filter – Impedance Plots for Filter Banks – Impedance Plots for a Three-Branch 33 kV Filter.		
UNIT – IV	**DSTATCOM**	**(9 Periods)**
Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.		
UNIT – V	**SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM**	**(9 Periods)**
Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – Voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*R. C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty,* ***"Electrical Power Systems Quality"****, McGraw-Hill Education, III Edition, 2017.*
2	*Sivaraman Palanisamy, Sanjeevikumar Padmanaban et al.,* ***"Power Quality in Modern Power Systems",*** *Elsevier, I Edition, 2020.*

REFERENCES:

1	*Arindam Ghosh and Gerard Ledwich,* ***"Power Quality Enhancement Using Custom Power Devices"****, Springer, I Edition, 2002.*
2	*Jos Arrillaga and Neville R. Watson,* ***"Power System Harmonics"****, Wiley, II Edition, 2003.*
3	*G. T. Heydt,* ***"Electric Power Quality"****, Stars in a Circle Publications, II Edition, 1994.*
4	*Derek A. Paice,* ***"Power Electronic Converter Harmonics"****, IEEE Press, I Edition, 1995.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Illustrate the importance of power quality and differentiate various power quality issues	K2
CO2	Explain the various concepts related with linear / nonlinear loads and single phase / three phase sinusoidal, non-sinusoidal sources.	K2
CO3	Identify the sources of harmonics and choose the methods for controlling the harmonic distortion	K3
CO4	Analyze load compensation with DSTATCOM	K4
CO5	Illustrate the role of DVR, SAFs UPQC in power distribution systems	K2

25WPE4E2	ENERGY AUDITING AND MANAGEMENT	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To comprehend energy management schemes and perform economic analysis and energy conservation in electrical and thermal systems	
UNIT – I	**BASICS OF ENERGY AUDIT AND MANAGEMENT**	**(9 Periods)**
Energy Security - Salient Features of Energy Conservation Act 2022 - Objectives of Energy Management - Energy Audit - Need - Types - Methodology - Audit Report - Instruments for Audit - BEE regulations.		
UNIT – II	**ACTION PLANNING AND MONITORING**	**(9 Periods)**
Energy Action Planning - Energy Cell - EnergyAuditor - Energy Manager - Eligibility - Roles and responsibilities - EnMS ISO (50001:2011) - Project management: Steps in detail. – Energy monitoring and interpretation of variances for remedial actions. Environmental concerns: UNFCC – Kyoto protocol – COP – CDM – PCF – Sustainable development.		
UNIT – III	**ENERGY ASSESSMENT OF THERMAL UTILITIES**	**(9 Periods)**
Boilers - Types - Performance Evaluation of Boilers–Energy Conservation Opportunity – Furnaces - Types – Fuel economy measures in furnaces - Cogeneration: Principle – Classification – Influencing Factors and technical parameters. Waste heat recovery: Classification – application – benefits - Different heat recovery devices		
UNIT – IV	**ENERGY ASSESSMENT OF ELECTRICAL UTILITIES**	**(9 Periods)**
Electricity Billing – Estimation and minimization of technical losses in distribution system - Motor efficiency and tests – Energy efficient motors – Effects of rewinding - VFD - Lighting System: Choice of lighting - Types and features – recommended luminance levels – Lighting design for interiors - energy saving opportunities - Case studies - ECBC.		
UNIT – V	**ENERGY ASSESSMENT IN UTILITY SYSTEMS**	**(9 Periods)**
Financial analysis techniques, ROI, Risk and sensitivity analysis - Payback period – methods – factors affecting analysis. Performance assessment of HVAC System - Pumps - Motors and variable speed drives - Measurements, Procedure – Evaluation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	Murphy W.R. and G.Mckay Butter worth , "*Energy Management*", Heinemann Publications, 2019.
2	Paul o' Callaghan, "*Energy Management*", Mc-Graw Hill Book Company – I edition; 2018

REFERENCES :

1	John.C.Andreas, "*Energy Efficient Electric Motors*", Marcel Dekker Inc Ltd – II edition; 2018
2	W.C.Turner, "*Energy Management Handbook*", John Wiley and Sons, Fifth edition, 2019
3	Albert Thumann, Terry Niehus and William J Younger, "*Handbook of Energy Audits*", Taylor & Francis, 2018
4	www.em-ea.org/gbook1.asp

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Observe energy audit and the document audit report	K2
CO2	Demonstrate energy management actions and develop the understanding of implementation	K3
CO3	Examine the operation of thermal utilities	K4
CO4	Plan the operation of electrical utilities	K4
CO5	Evaluate financial analysis and assess different utility systems.	K5

25WPE4E3	POWER SYSTEM ECONOMICS	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart knowledge on the economic principles underlying the operation and planning of the electricity systems including concepts of electricity markets and competition in electricity generation and supply and the opening of the transmission and distribution systems to third party access.	
UNIT – I	**POWER MARKET**	**(9 Periods)**
Structure and operation: Objective of market operation, Electricity market models-Power market types-Market power -Key components in market operation. Demand - supply, Demand analysis – Theory, elasticity of demand, Demand forecasting –Types, techniques. Costs: Short run – Long run - Relationship between short run -long run costs, perfect competition – Monopoly- Monopolistic - Oligopolistic, Determination of market price, Price discrimination		
UNIT – II	**ELECTRICITY PRICE**	**(9 Periods)**
Price volatility-ancillary services in electricity power market-automatic generation control -its pricing, Generation assets valuation- risk analysis. -Introduction, VAR for Generation Asset Valuation, Generation Capacity Valuation.		
UNIT – III	**TRANSMISSION CONGESTION MANAGEMENT AND PRICING**	**(9 Periods)**
Transmission cost allocation methods- Local Marginal Price- Financial Transmission Right - Congestion Management- Role of Flexible AC Transmission System devices in competitive power market-Available Transfer Capability-Distributed Generation in restructured markets.		
UNIT – IV	**REACTIVE POWER MARKET MANAGEMENT**	**(9 Periods)**
Reactive power requirements under steady state voltage stability -dynamic voltage stability, reactive power requirements to cover transient voltage stability-System losses - loss reduction methods- Power tariffs - Market Forces shaping of reactive power- reactive power requirement of the utilities.		
UNIT – V	**RELIABILITY ANALYSIS OF GENERATION SYSTEM**	**(9 Periods)**
Characteristic operation of power plants - Choice of power plants - Hydro, Thermal - Nuclear - Size of plant – Input / Output curves. Economic Planning - Generation system - Cost analysis - Capacity cost -Production cost - Plant cost - Timing of unit additions - System cost analysis. Load forecasting -system reliability: Load forecasting - Generation system reliability - Co-ordination methods - Economic operation of power systems - Simple problems.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*E. K. Kirchmayer, "Economic Operation of Power Systems"***,** *Wiley India Pvt. Ltd., Latest Reprint Edition, 2017.*
2	***Daniel S. Kirschen and Goran Strbac, "****Fundamentals of Power System Economics", II Edition, Wiley, 2018.*

REFERENCES:

1	*R. R. Barathwal,* ***"Industrial Economics: An Introductory Textbook"****, New Age International Publishers, IV Edition, 2021.*
2	*Wayne C. Turner and Steve Doty,* ***"Energy Management Handbook"****, Fairmont Press, IX Edition, 2018.*
3	*D. M. Tagare,* ***"Reactive Power Management"****, Tata McGraw-Hill, I Edition, 2017.*
4	*S. K. Jain, "Applied Economics for Engineers and Managers"****,*** *CBS Publishers & Distributors Pvt. Ltd., 2nd Edition, 2010.*

COURSE OUTCOMES: - On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Elaborate the principles of power system economics.	K2
CO2	Apply market/managerial economic aspects.	K3
CO3	Illustrate the social efficiency concepts.	K2
CO4	Analyze power systems with application of economics considerations.	K5
CO5	Assess electric power system for socio-economic standpoint.	K5

25WPE4E4	RESTRUCTURED POWER SYSTEMS	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To obtain knowledge about Indian power markets and deregulation	
UNIT – I	INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY	(9 Periods)

Introduction-Reasons for restructuring / deregulation of power industry-Understanding the restructuring process - Entities involved-The levels of competition-The market place mechanisms-Sector-wise-issues involved in deregulation-objectives of deregulation of various power systems across the world. Fundamentals of Economics -Consumer behavior-Supplier behavior- Market equilibrium, Short-run - Long-run costs, Various costs of production, Relationship between short-run - long-run average costs-Perfectly competitive market- Policies of restructured environment.

UNIT – II	MARKET MODELS AND TRANSMISSION CONGESTION MANAGEMENT	(9 Periods)

Market models based on contractual arrangements-Comparison of various market models-Electricity vis-à-vis other commodity - Four pillars of market design.- Market architecture-Definition of congestion-transfer capability limitation-Importance of congestion management in deregulated environment-features of congestion management schemes-Classification of congestion management methods-Calculation of ATC - Definition of various terms-ATC calculation using PTDF -LODF based on DC model-Calculation of ATC using AC model- Non-market methods-Market based methods- Nodal pricing- Inter-zonal- Intra-zonal congestion management-Price area congestion management- Capacity alleviation method.

UNIT – III	LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS	(9 Periods)

Mathematical preliminaries - Fundamentals of locational marginal pricing-Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation-Financial Transmission Rights-Risk Hedging Functionality of Financial Transmission Right - Simultaneous feasibility test - revenue adequacy - FTR issuance process-Treatment of revenue shortfall -Secondary trading of FTRs - Flow Gate rights - FTR -market power - FTR - merchant transmission investment.

UNIT – IV	ANCILLARY SERVICES AND TRANSMISSION PRICING	(9 Periods)

Introduction to ancillary services-Types of ancillary services-Classification of ancillary services, Load-generation balancing related services-Voltage control - reactive power support services-Black start capability service-Co-optimization of energy -reserve services, International comparison-Pricing of transmission network usage -loss allocation - transmission pricing-Principles of transmission pricing-Classification of transmission pricing method-Rolled-in transmission pricing methods- Marginal transmission pricing paradigm-Composite pricing paradigm-Merits -de-merits of different paradigms-Debated issues in transmission pricing- loss allocation-Classification of loss allocation methods - comparison.

UNIT – V	POWER MARKETS AND REFORMS IN INDIAN POWER SECTOR	(9 Periods)

Attributes of a perfectly competitive market-The firm's supply decision under perfect competition-Imperfect competition - Market power - Financial markets associated with electricity markets-optimal bidding by a generator company - Optimal bidding methods-Reforms in Indian power sector: Framework of Indian power sector-Reform initiatives during 1990-1995-Availability Based Tariff (ABT)-The Electricity Act 2003- Open Access issues -Power exchange - Reforms in near future.

Contact Periods:			
Lecture:45 Periods	**Tutorial: 0 Periods**	**Practical: 0 Periods**	**Total: 45 Periods**

TEXT BOOKS:

1	*Kankar Bhattacharya, Jaap E. Daalder and Math H. J. Bollen, "Operation of Restructured Power Systems"***,** *Springer, II Edition (Reprint), 2012.*
2	*Loi Lei Lai,* ***"Power System Restructuring and Deregulation"****, Wiley, I Edition, 2001.*

REFERENCES:

1	*Daniel S. Kirschen and Goran Strbac,* ***"Fundamentals of Power System Economics"****, Wiley, II Edition, 2018.*
2	*Xiao-Ping Zhang,* ***"Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models",*** *Wiley-IEEE Press, I Edition, 2010.*
3	*S. A. Khaparde and A. R. Abhyankar,* ***"Restructured Power Systems",*** *Alpha Science International, I Edition, 2006.*
4	*Steven Stoft,* ***"Power System Economics: Designing Markets for Electricity"****, Wiley-IEEE Press, I Edition, 2002.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate the new dimensions associated with the power systems with techno-commercial issues	K2
CO2	Apply various solutions for the commercial problems through study of fundamentals of micro economics	K3
CO3	Design power markets and market architectural aspects as per the restructuring of power system	K4
CO4	Identify operational challenges and manage the same with optimum solution	K5
CO5	Suggest reform practices in developing countries with special focus on Indian power system	K6

25WPE4E5	ELECTRICAL SAFETY AND QUALITY MANAGEMENT	SEMESTER IV

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To obtain knowledge about Electrical Safety and Quality Management.	
UNIT – I	**REVIEW OF IE RULES AND ACTS AND THEIR SIGNIFICANCE**	**(9 Periods)**
Objective and scope – Ground clearances and section clearances – Standards on electrical safety - Safe limits of current, voltage - Earthing of system neutral – Rules regarding first aid and firefighting facility.		
UNIT – II	**ELECTRICAL SAFETY IN RESIDENTIAL, COMMERCIAL AND AGRICULTURAL INSTALLATIONS**	**(9 Periods)**
Wiring and fitting – Domestic appliances – Water tap giving shock – Shock from wet wall – Fan Firing shock –Multi-storeyed building – Temporary installations –Agricultural pump installation – Do's and Don'ts for safety in the use of domestic electrical appliances.		
UNIT – III	**SAFETY DURING INSTALLATION, TESTING AND COMMISSIONING, OPERATION AND MAINTENANCE**	**(9 Periods)**
Hazardous zones – class 0,1 and 2 – spark, flashovers and corona discharge and functional requirements – Specifications of electrical plants, equipment's for hazardous locations – Classification of equipment enclosure for various hazardous gases and vapours – Classification of equipment/enclosure for hazardous locations.		
UNIT – IV	**ELECTRICAL SAFETY IN HAZARDOUS AREAS**	**(9 Periods)**
Hazardous zones – class 0,1 and 2 – spark, flashovers and corona discharge and functional requirements – Specifications of electrical plants, equipment's for hazardous locations – Classification of equipment enclosure for various hazardous gases and vapours – Classification of equipment/enclosure for hazardous locations.		
UNIT – V	**QUALITY MANAGEMENT**	**(9 Periods)**
Total quality control and management – Importance of high load factor – Disadvantages of low power factor – Causes of low P.F. – Power factor improvement – Equipment – Importance of P.F. improvement.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*S. Rao, R.K.Jain, H.L. Saluja, "**Electrical Safety, Fire Safety Engineering and Safety Management",** II Edition, Khanna Publishers, New Delhi, 2012.*
2	*Al Winfield, Mary Capelli-Schellpfeffer and Dennis Neitzel, **"Electrical Safety Hand Book",** McGraw Hill Publications, 2018.*

REFERENCES:

1	*Martha J. Boss, Gayle Nicoll,* ***"Electrical Safety: Systems, Sustainability, and Stewardship",*** *CRC Press, 2014.*
2	*Peter E. Sutherland,* ***"Principles of Electrical Safety",*** *IEEE Press, Wiley, 2025.*
3	*W. Fordham-Cooper,* ***"Electrical Safety Engineering",*** *Newnes, 2002.*
4	*Institution of Engineering and Technology (IET),* ***"Electrical Safety Management: Code of Practice"****, II Edition, IET Publications, 2023.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the IE rules and its significance.	K2
CO2	Explain the electrical safety in residential, commercial and agricultural installations.	K2
CO3	Illustrate the electrical safety during installation, testing and commissioning, operation and maintenance.	K2
CO4	Illustrate electrical safety in hazardous areas.	K2
CO5	Explain about quality management.	K2

ELECTIVE -II

25WPE5E1	BIOMEDICAL INSTRUMENTATION	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide an overview about the human physiological system, instrumentation system for measuring and analyzing the physiological parameters	
UNIT – I	**PHYSIOLOGY**	**(9 Periods)**
Cell and its structure - Resting and action potential - Physiology of circulatory system, Respiratory system, Nervous system - Bio-potential electrodes - Types of electrode - Electrode behavior and circuit models - Transducers for biomedical applications.		
UNIT – II	**ELECTRO PHYSIOLOGICAL MEASUREMENT AND SAFETY**	**(9 Periods)**
Classification of biological signals: ECG, EEG, EMG, ERG, EOG Lead system and recording methods - Typical waveforms – Electrical Safety in medical environment – Shock hazards – Leakage Current – Instruments to protect against electrical hazards.		
UNIT – III	**NON- ELECTRICAL PARAMETER MEASUREMENTS AND TELEMETRY**	**(9 Periods)**
Measurement of Blood pressure, Blood flow, Cardiac output – Plethysmography - Measurement of heart sounds - Blood gas analysers - Oximeters - Biotelemetry		
UNIT – IV	**MEDICAL IMAGING SYSTEMS**	**(9 Periods)**
X-ray Machine - Computer Radiography - Computed Tomography - Magnetic Resonance Imaging - Ultrasonic Imaging Systems - Positron Emission Tomography - Single Photon Emission Computer – Tomography – Thermography - Endoscopy.		
UNIT – V	**ASSISTING AND THERAPEUTIC DEVICE**	**(9 Periods)**
Pacemakers – Defibrillators – Ventilator - Nerve and muscle stimulator - Heart lung machine - Kidney machine – Audiometers – Diathermy - Application of Lasers in biomedicine.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, **"Biomedical Instrumentation and Measurements"**, Pearson Education, II Edition, 2017.*
2	*R. S. Khandpur, **"Handbook of Biomedical Instrumentation"**, McGraw-Hill Education, III Edition, 2014.*

REFERENCES:

1	*Andrew G. Webb,* ***"Principles of Biomedical Instrumentation"****, Cambridge University Press, I Edition, 2018.*
2	*John G. Webster (Ed.),* ***"Medical Instrumentation: Application and Design"****, Wiley India, IV Edition, 2015*
3	*James E. Moore Jr. and Duncan J. Maitland,* ***"Biomedical Technology and Devices Handbook"****, CRC Press, II Edition, 2013.*
4	*Joseph J. Carr and John M. Brown,* ***"Introduction to Biomedical Equipment Technology"****, Pearson Education, IV Edition, 2001.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the physical foundations of biological systems and the various electrodes used in the medical field.	K2
CO2	Discuss about the various electro physiological measurements in the human body and electrical safety.	K2
CO3	Apply the appropriate medical instrument for the measurement of non-electrical parameters of the human body.	K2
CO4	Compare the various medical imaging techniques and their applications.	K2
CO5	Describe the working of medical assisting and therapy equipment.	K2

25WPE5E2	THERMAL POWER PLANT INSTRUMENTATION	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart knowledge on the process variables, measurements and control loops used in thermal power plants.	
UNIT – I	**METHODS OF POWER GENERATION**	**(9 Periods)**
Methods of Power Generation: Hydro, Thermal, Nuclear, Solar and Wind - Importance of Instrumentation in Power Generation -Basic Building Block for all Types of Power Generation Plants - Details of Boiler Processes - P and I Diagram of Boiler - Cogeneration.		
UNIT – II	**MEASUREMENTS IN POWER PLANTS**	**(9 Periods)**
Measurement of Feed Water Flow, Air Flow, Steam Flow and Coal Flow - Drum Level Measurement- Temperature Measurement- Steam Pressure Measurement.		
UNIT – III	**ANALYZERS IN POWER PLANTS**	**(9 Periods)**
Analysis of Impurities in Feed Water and Steam - Oxygen Analyzer - Dissolved Oxygen Analyzer - Chromatography - pH Meter - Fuel Analyzer - Flue Gas Analyzer - Pollution Monitoring Instruments.		
UNIT – IV	**CONTROL LOOPS IN BOILER**	**(9 Periods)**
Combustion Control: Air/Fuel Ratio Control, Furnace Draft Control - Drum Level Control - Main Steam and Reheat Steam Temperature Control – Superheater Control – Attemperator - Deaerator Control - Interlocks in Boiler Operation - Distributed Control System in Power Plants.		
UNIT – V	**TURBINE AND ITS CONTROL**	**(9 Periods)**
Types of Steam Turbines: Impulse and Reaction Turbines - Compounding - Turbine Governing System - Free Governor Mode Operation - Turbine Run up System - Turbine Speed and Vibration Measurement - Speed Control - Automatic Load Frequency Control - Safety Control System - Turbo Alternator lubrication and Cooling System.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*K. Krishnaswamy and M. Ponnibala,* ***"Power Plant Instrumentation"****, PHI Learning, II Edition, 2013.*
2	*Sam G. Dukelow,* ***"The Control of Boilers"****, Instrument Society of America, II Edition, 1991.*

REFERENCES:

1	*Béla G. Lipták,* ***"Instrument Engineers' Handbook: Process Measurement and Analysis"****, CRC Press, IV Edition, 2016.*
2	*A. B. Gill,* ***"Power Plant Performance"****, Butterworth-Heinemann, I Edition, 2016.*
3	*R. K. Jain,* ***"Mechanical and Industrial Measurements"****, Khanna Publishers, XII Edition, 2015.*
4	*David Lindsley,* ***"Boiler Control Systems"****, McGraw-Hill, I Edition, 1991.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the different methods of generating power	K2
CO2	Select suitable instruments for various process measurements in power plants	K2
CO3	Describe the operation of different analysers used in power plants	K2
CO4	Analyze the control strategies implemented in different stages of power plant	K3
CO5	Elaborate on the types of turbines, their related measurements and control	K2

25WPE5E3	MEMS AND NEMS	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To introduce the concepts of micro and nanoelectromechanical devices. To learn the fabrication process of MEMS for the design of MEMS devices	
UNIT – I	**INTRODUCTION TO MEMS AND NEMS**	**(9 Periods)**
Introduction to Design of MEMS and NEMS, Overview of Nano and Microelectromechanical Systems, Applications of Micro and Nanoelectromechanical systems, Materials for MEMS and NEMS: Silicon, silicon compounds, polymers, metals.		
UNIT – II	**MEMS FABRICATION TECHNOLOGIES**	**(9 Periods)**
Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, Sputtering Etching techniques, Micromachining: Bulk Micromachining, Surface Micromachining, LIGA.		
UNIT – III	**MICROSENSORS**	**(9 Periods)**
MEMS Sensors: Design of Acoustic wave sensors, Vibratory gyroscope, Capacitive Pressure sensors, Case study: Piezoelectric energy harvester		
UNIT – IV	**MICRO ACTUATORS**	**(9 Periods)**
Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces, Case Study: RF Switch.		
UNIT – V	**NANODEVICES**	**(9 Periods)**
Atomic Structures and Quantum Mechanics, Schrodinger Equation, ZnO nanorods based NEMS device: Gas sensor.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Chang Liu, **"Foundations of MEMS"**, Prentice Hall, II Edition, 2012.*
2	*Sergey Edward Lyshevski, **"MEMS and NEMS: Systems, Devices, and Structures"**, CRC Press, I Edition, 2002.*

REFERENCES:

1	*Tai-Ran Hsu, **"MEMS and Microsystems: Design and Manufacture"**, Wiley, II Edition, 2020.*
2	*Marc J. Madou, **"Fundamentals of Microfabrication and Nanotechnology"**, CRC Press, III Edition, 2012.*
3	*Mohamed Gad-el-Hak (Ed.), **"The MEMS Handbook"**, CRC Press, II Edition, 2005.*
4	*Nitaigour Premchand Mahalik, **"MEMS"**, McGraw-Hill Education, I Edition, 2009.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Illustrate the basics of micro / nanoelectromechanical systems	K2
CO2	Recognize the material properties of MEMS performance	K2
CO3	Demonstrate the MEMS fabrication process	K3
CO4	Develop models and simulate sensors and actuators	K5
CO5	Recall the foundation of nanodevices	K1

25WPE5E4	IoT FOR ELECTRICAL ENGINEERING	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To outline Smart Objects and IoT Architectures and functional stacks, various IOT-related protocols, build simple IoT Systems using Arduino and Raspberry Pi, data analytics and cloud in the context of IoT to apply IoT infrastructure for Electrical Power Industry	
UNIT – I	**FUNDAMENTALS OF IoT**	**(9 Periods)**
Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects.		
UNIT – II	**IoT PROTOCOLS**	**(9 Periods)**
IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT		
UNIT – III	**DESIGN AND DEVELOPMENT**	**(9 Periods)**
Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.		
UNIT – IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**(9 Periods)**
Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG.		
UNIT – V	**IoT in ELECTRICAL POWER INDUSTRY**	**(9 Periods)**
IoT in the Electrical Power Industry – SCADA, Smart Grids, Power transmission line state monitoring, Effective Power Conservation, Smart Metering, Advanced Metering Infrastructure, Building Automation, Connected Public Lighting, Smart Grid, Smart Inverters, Remote control operation of energy consuming devices.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Kamlesh Lakhwani, Hemant Kumar Gianey, Joseph Kofi Wireko and Kamal Kant Hiran,* ***"Internet of Things: Principles, Paradigms and Applications"****, BPB Publications, I Edition, 2020.*
2	*Raj Kamal,* ***"Internet of Things: Architecture and Design Principles",*** *McGraw Hill Education, II Edition, 2017*

REFERENCES:

1	*Michael Margolis,* ***"Arduino Cookbook"****, O'Reilly Media, III Edition, 2020.*
2	*Vlasios Tsiatsis, Stamatis Karnouskos, Jan Holler, David Boyle and Catherine Mulligan,* ***"Internet of Things: Technologies and Applications for a New Age of Intelligence"****, Academic Press, II Edition, 2018.*
3	*David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry,* ***"IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things"****, Cisco Press, I Edition, 2017.*
4	*Arshdeep Bahga and Vijay Madisetti,* ***"Internet of Things: A Hands-On Approach"****, Universities Press, I Edition, 2015.*
5	*Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand and David Boyle,* ***"From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence"****, Elsevier, I Edition, 2014.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of IoT.	K2
CO2	Analyze various protocols for IoT	K4
CO3	Design and develop a PoC of an IoT system using Raspberry Pi/Arduino	K6
CO4	Apply data analytics and use cloud offerings related to IoT	K3
CO5	Identify and evaluate the application of IoT to the Electric Power Industry	K5

25WPE5E5	SOFT COMPUTING TECHNIQUES	SEMESTER V

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide in-depth knowledge on the fundamentals of intelligent systems, their applications and develop intelligent solutions to real world problems.

UNIT – I	INTRODUCTION TO SOFT COMPUTING	(9 Periods)

Soft Computing Constituents – From Conventional AI to Computational Intelligence - Soft computing versus Hard computing - Neural Networks Basic structure of ANN and Fuzzy Logic System - Introduction to Nature inspired search methodologies - Basic idea of Genetic Algorithm - Application scope of ANN, Fuzzy Logic and Genetic Algorithms.

UNIT – II	ARTIFICIAL NEURAL NETWORKS	(9 Periods)

McCulloch-Pitts neuron - linear separability - Hebb network - supervised learning networks: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron, BPN. Associative memory network: auto-associative memory network, hetero-associative memory network, Bi-directional Associative Memory (BAM), Hopfield networks. Unsupervised learning networks: Kohonen self-organizing feature maps – Counter Propagation networks, Adaptive Resonance Theory network.

UNIT – III	FUZZY SYSTEMS	(9 Periods)

Membership functions: features, fuzzification, methods of membership value assignments-Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning: truth values and tables, fuzzy propositions, formation of rules-decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making.

UNIT – IV	GENETIC ALGORITHMS	(9 Periods)

Introduction- Biological Background –Genetic Algorithm (GA) vs. Traditional Algorithm – Basic Terminologies in GA: Individuals-Genes-Fitness-Population- Operators in GA:Encoding-Selection – Crossover – Mutation – Constraints in GA- Real coded GA.

UNIT – V	HYBRID SYSTEMS	(9 Periods)

Neuro-Fuzzy Hybrid Systems – Genetic Neuro-Hybrid Systems - Genetic Fuzzy Hybrid and Fuzzy Genetic Hybrid System – Simplified Fuzzy ARTMAP – Applications of Soft Computing techniques to simple problems

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOK:

1	*S.N.Sivanandam , S.N.Deepa, "**Principles of Soft Computing**", Wiley India Pvt.Ltd., 3rd Edition, 2018.*
2	*S.Rajasekaran, G.A.Vijayalakshmi Pai, "**Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications** ", PHI Learning Pvt.Ltd., 2017.*

REFERENCES:

1	*Jyh-Shing Roger Jang, Chuen-Tsai Sun and Eiji Mizutani, **"Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence",** Pearson Education, Revised Edition, 2025.*
2	*Kwang H.Lee, **"First course on Fuzzy Theory and Applications"**, Springer, 2005.*
3	*George J. Klir and Bo Yuan, **"Fuzzy Sets and Fuzzy Logic-Theory and Applications"**, Pearson Education India, First Edition, 2015.*
4	*James A. Freeman and David M. Skapura, **"Neural Networks Algorithms, Applications, and Programming Techniques**", Pearson Education India, Reprint Edition, 2013.*
5	*N.P.Padhy, S.P.Simon, "**Soft Computing with MATLAB Programming**", Oxford University Press, 2015.*

COURSE OUTCOMES: **On completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Explain about soft computing techniques and their roles in building intelligent systems.	**K2**
CO2	Examine the artificial neural networks to classification and regression problems.	**K3**
CO3	Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems.	**K3**
CO4	Implement the combinatorial optimization problems using genetic algorithms	**K3**
CO5	Evaluate the hybridization of different intelligent techniques for solving complex problems.	**K5**

ELECTIVE – III

25WPE6E1	SMART GRID TECHNOLOGY	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide a comprehensive understanding of Smart Grid Technology, including its components, functions, applications and implications for Energy Management and Distribution.	
UNIT – I	**BASICS OF POWER SYSTEMS**	**(9 Periods)**
Basics of Power Systems: Load and Generation - Power Flow Analysis- Economic Dispatch and Unit Commitment Problems. Smart Grid: Definition – Applications- Government and Industry- Standardization		
UNIT – II	**SMART GRID COMMUNICATIONS**	**(9 Periods)**
Two-way Digital Communications Paradigm - Network Architectures - IP-based Systems - Power Line Communications - Advanced Metering Infrastructure.		
UNIT – III	**WIDE AREA MEASUREMENT**	**(9 Periods)**
Sensor Networks - Phasor Measurement Units- Communications Infrastructure- Fault Detection and Self-Healing Systems -Applications and Challenges.		
UNIT – IV	**SECURITY AND PRIVACY**	**(9 Periods)**
Cyber Security Challenges in Smart Grid - Load Altering Attacks- False Data Injection Attacks- Defense Mechanisms - Privacy Challenges- Cyber Security Standards.		
UNIT – V	**ECONOMICS AND MARKET OPERATIONS**	**(9 Periods)**
Introduction, Reasons for restructuring / deregulation of power industry, Understanding the restructuring process - Entities involved. The market place mechanisms-Energy and Reserve Markets- Market Power - Generation Firms- Locational Marginal Prices- Financial Transmission Rights.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu and Akihiko Yokoyama,* ***"Smart Grid: Technology and Applications",*** *Wiley India, Reprint Edition, 2015.*
2	*P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan,* ***"Electrical Power Systems: Analysis, Security and Deregulation"****, PHI Learning, II Edition, 2017.*

REFERENCES :

1	*Bharat Modi, Anu Prakash and Yogesh Kumar* ***"Fundamentals of Smart Grid Technology",*** *S. K. Kataria & Sons, I Edition, 2015, Reprint 2022.*
2	*Lars T. Berger and Krzysztof Iniewski,* ***"Smart Grid Applications, Communications and Security"****, Wiley India Pvt. Ltd., Reprint Edition, 2015.*
3	*Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Nick Jenkins, Lars T. Berger, Krzysztof Iniewski and James Momoh* ***"Smart Grid: Fundamentals, Design, Technology, Applications, Communication and Security – An Indian Adaptation",*** *Wiley India, 2021.*
4	*Yang Xiao,* ***"Communication and Networking in Smart Grids"****, CRC Press, I Edition, 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recollect the fundamentals of conventional power systems and learn the concept of smart grid	K1
CO2	Interpret the role of communication Technologies in a smart grid	K2
CO3	Apply the state-of-the-art measurement and protection techniques for reliable grid	K3
CO4	Utilize the techniques for ensuring safety and security of the smart grid	K3
CO5	Analyze the economic aspects of the smart grids	K4

25WPE6E2	ENERGY STORAGE TECHNOLOGY	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To explore the fundamentals, technologies and applications of energy storage system.	
UNIT – I	HISTORICAL PERSPECTIVE OF ENERGY STORAGE SYSTEM	(9 Periods)
Storage Needs - Variations in Supply and energy demand Interruptions in Energy Supply- Transmission Congestion - Demand for Portable Energy-Demand and scale requirements - Environmental and sustainability issues.		
UNIT – II	CLASSIFICATION OF STORAGE SYSTEM	(9 Periods)
Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs)- Kinetic energy (mechanical flywheels)- Thermal energy without phase change passive (adobe) and active (water)-Thermal energy with phase change (ice, molten salts, steam)- Chemical energy (hydrogen, methane, gasoline, coal, oil)-Electrochemical energy (batteries, fuel cells)- Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets)- Different Types of Energy Storage Systems.		
UNIT – III	PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS	(9 Periods)
Energy capture rate and efficiency- Discharge rate and efficiency- Dispatch ability and load flowing characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity- Ease of materials, recycling and recovery- Environmental consideration and recycling, Merits and demerits of different types of Storage. Comparison of Storage Technologies- Technology options- Performance factors and metrics- Efficiency of Energy Systems- Energy Recovery.		
UNIT – IV	BATTERY AND THERMAL ENERGY STORAGE SYSTEMS	(9 Periods)
Battery Storage System: Lead Acid and Lithium- Chemistry of Battery Operation, Power storage calculations, Charging patterns, Battery Management systems -Areas of Application of Energy Storage: Waste heat recovery- Solar energy storage- Greenhouse Heating-Power plant applications-Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.		
UNIT – V	HYDROGEN FUEL CELLS AND FLOW BATTERIES	(9 Periods)
Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations – Operation and Design methods - Hybrid Energy Storage: Managing peak and Continuous power needs, Hybrid energy storage: battery and supercapacitor combination, need, operation and Merits; Flow Battery Operation- Applications: Storage for Hybrid Electric Vehicles-Regenerative Power-capturing methods.		
Contact Period: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Detlef Stolten and Bernd Emonts,* ***"Hydrogen Science and Engineering: Materials, Processes, Systems and Technology"****, Wiley-VCH, II Edition, 2016.*
2	*Robert Huggins,* ***"Energy Storage: Fundamentals, Materials and Applications"****, Springer, 2nd Edition, 2016.*

REFERENCES :

1	*Paul Breeze,* ***"Energy Storage Technologies"****, Academic Press (Elsevier), I Edition, 2018.*
2	*Jiujun Zhang, Lei Zhang, Hansan Liu and Andy Sun,* ***"Electrochemical Energy Storage"****, CRC Press, I Edition, 2012.*
3	*François Béguin and Elżbieta Frąckowiak,* ***"Supercapacitors: Materials, Systems and Applications"****, Wiley-VCH Verlag GmbH & Co. KGaA, I Edition, 2013.*
4	*Imre Gyuk, Paul Denholm and Sila Kiliccote,* ***"Grid Energy Storage"****, U.S. Department of Energy, I Edition, 2013.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge on the evolution and technologies of energy storage systems	K2
CO2	Summarize the basics of different energy storage mechanisms.	K2
CO3	Evaluate the performance factors of energy storage systems.	K5
CO4	Identify the field of applications for renewable energy systems.	K4
CO5	Explore the possibilities of hybrid energy storage techniques and applications.	K3

25WPE6E3	SPECIAL MACHINES AND CONTROLLERS	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To grasp the principle of working of special electrical machines and to cater the knowledge to real world applications.	
UNIT – I	**STEPPING MOTORS**	**(9 Periods)**
Constructional features – Principle of operation – Modes of excitation – Torque production in Variable Reluctance (VR) stepping motor – Dynamic characteristics – Drive systems and circuit for open loop control– Closed loop control of stepping motor.		
UNIT – II	**SWITCHED RELUCTANCE MOTORS**	**(9 Periods)**
Constructional features – Principle of operation – Torque equation – Power controllers – Characteristics and control: Speed control-current control- Sensor less operation of SRM – Current sensing- rotor position measurement and estimation methods- sensor less rotor position estimation-inductance based estimation - Microprocessor based controller.		
UNIT – III	**SYNCHRONOUS RELUCTANCE MOTORS**	**(9 Periods)**
Constructional features –Types –Axial and radial air gap motors –Phasor diagram – Characteristic and Control - Vernier motor – Applications.		
UNIT – IV	**PERMANENT MAGNET BRUSHLESS DC MOTORS**	**(9 Periods)**
Commutation in DC motors – Difference between mechanical and electronic commutators – Hall sensors – Optical sensors – Multiphase Brushless motor – Square wave permanent magnet brushless motor drives – Torque and emf equation – Torque and Speed characteristics – Microprocessor based controller.		
UNIT – V	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**(9 Periods)**
Constructional features - Principle of operation – EMF, power input and torque expressions – Phasor diagram – Power controllers – Torque and Speed characteristics –Current and Speed control - Self-control – Vector control – Current control schemes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*R. Krishnan, **"Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications"**, CRC Press, I Edition, 2001.*
2	*E. G. Janardanan, **"Special Electrical Machines",** PHI Learning Pvt. Ltd., I Edition, 2014.*

REFERENCES:

1	*Berker Bilgin, Ali Emadi and James Weisheng Jiang,* ***"Switched Reluctance Motor Drives: Fundamentals to Applications"****, CRC Press, I Edition, 2019.*
2	*Jigneshkumar P. Desai,* ***"Special Electrical Machinery"****, Wiley, I Edition, 2024.*
3	*Ramu Krishnan,* ***"Permanent Magnet Synchronous and Brushless DC Motor Drives"****, CRC Press, I Edition, 2010.*
4	*Jacek F. Gieras, Rong-Jie Wang and Maarten J. Kamper,* ***"Axial Flux Permanent Magnet Brushless Machines"****, Springer, II Edition, 2008.*
5	*T. J. E. Miller,* ***"Brushless Permanent-Magnet and Reluctance Motor Drives"****, Clarendon Press, I Edition, 1989.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe the constructional features, principle of operation and the types of special electrical machines	K2
CO2	Compute the Torque and EMF equations of the special electrical machines	K3
CO3	Interpret the static and dynamic characteristics of the special electrical machines	K3
CO4	Examine various converter circuits for special electrical machines	K3
CO5	Develop different controllers for special electrical machines.	K4

25WPE6E4	FACTS CONTROLLERS	SEMESTER VI

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To enrich the knowledge about the functions and characteristics of FACTS controllers and to identify their suitability for various applications.	
UNIT – I	**INTRODUCTION TO POWER TRANSMISSION CONTROL**	**(9 Periods)**
The concept of flexible AC transmission - Reactive power control in electrical power transmission lines - Uncompensated transmission line – Series and shunt compensation. Calculation of surge impedance loading and midpoint voltage, Transmission problems and needs: the emergence of FACTS- Objectives of FACTS - Thyristor Controlled FACTS Controllers and Converter Based FACTS Controllers.		
UNIT – II	**STATIC VAR COMPENSATOR AND APPLICATIONS**	**(9 Periods)**
Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage. Applications - Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.		
UNIT – III	**THYRISTOR CONTROLLED SERIES CAPACITOR AND APPLICATIONS**	**(9 Periods)**
Operation of the TCSC - Different modes of operation – Modeling of TCSC – Variable reactance model – Modeling for stability studies. Applications - Improvement of the system stability limit – Enhancement of system damping – Voltage collapse prevention.		
UNIT – IV	**ADVANCED FACTS CONTROLLERS**	**(9 Periods)**
Static Synchronous Compensator (STATCOM) – Operating principle – V-I characteristics Unified Power Flow Controller (UPFC) – Principle of operation - Modes of operation – Applications – Modeling of UPFC for power flow studies, Interline Power Flow Controllers (IPFC) - Basic Operating Principles and Characteristics, Control Structures.		
UNIT – V	**COORDINATION OF FACTS CONTROLLERS**	**(9 Periods)**
Controller Interactions – SVC-SVC, SVC-TCSC and TCSC-TCSC interactions- Coordination of multiple controllers using linear techniques (Quantitative Treatment)		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*K. R. Padiyar, **"FACTS Controllers in Power Transmission and Distribution"**, New Age International Publishers, III Edition, 2022.*
2	*R. Mohan Mathur and Rajiv K. Varma, **"Thyristor-Based FACTS Controllers for Electrical Transmission Systems"**, Wiley-IEEE Press, I Edition, 2002.*

REFERENCES:

1	*Xiao-Ping Zhang, Christian Rehtanz and Bikash Pal,* ***"Flexible AC Transmission Systems: Modelling and Control"****, Springer-Verlag Berlin Heidelberg, II Edition, 2012.*
2	*Kalyan K. Sen and Mey Ling Sen,* ***"Introduction to FACTS Controllers: Theory, Modeling, and Applications"****, Wiley-IEEE Press, I Edition, 2009.*
3	*Narain G. Hingorani and László Gyugyi,* ***"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems"****, Wiley-IEEE Press, I Edition, 2000.*
4	*Yong Hua Song and Allan T. Johns,* ***"Flexible AC Transmission Systems (FACTS)"****, The Institution of Engineering and Technology (IET), I Edition, 1999.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the problems and issues associated with AC transmission systems	K2
CO2	Summarize the operation and control of various FACTS Controllers	K5
CO3	Develop the modeling of various FACTS Controllers	K3
CO4	Analyze the performance of Power System with FACTS Controllers	K4
CO5	Suggest suitable FACTS device for enhancing the transmission capability	K5

25WPE6E5	AUTOMOTIVE ELECTRONICS FOR ELECTRICAL ENGINEERING	SEMESTER VI

PRE REQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To explore the role of electronic systems, in-vehicle networking and comfort/safety in automotive control applications.	
UNIT – I	**FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS**	**(9 Periods)**
Evolution of electronics in automobiles, emission laws, introduction to Euro standards, equivalent Bharat standards, charging systems: Working and design of charging circuit, alternators, requirements of starting system, starter motors and starter circuits.		
UNIT – II	**IGNITION AND INJECTION SYSTEMS**	**(9 Periods)**
Ignition systems: Ignition fundamentals, Electronic Ignition system, programmed ignition, distribution less ignition, direct ignition, spark plugs, Electronic fuel control, basics of combustion, engine fueling and exhaust emission, electronic control of carburetion, petrol fuel injection, diesel fuel injection.		
UNIT – III	**SENSORS AND ACTUATORS**	**(9 Periods)**
Working principle and characteristics of airflow rate, engine crankshaft angular position, hall effect, throttle angle, temperature, exhaust gas oxygen sensors. Fuel injector, exhaust gas recirculation actuators, stepper motor actuator and vacuum operated actuator.		
UNIT – IV	**ENGINE CONTROL SYSTEM**	**(9 Periods)**
Control modes for fuel control, engine control subsystems, ignition control methodologies, different ECUs used in engine management. Vehicle networks: CAN standard. Diagnostic systems in modern automobiles.		
UNIT – V	**CHASSIS AND SAFETY SYSTEMS**	**(9 Periods)**
Traction control system, cruise control system, electronic control of automatic transmission, antilock braking system, electronic suspension system, working of airbag, centralized door locking system, climate control of cars.		
Contact Periods: **Lecture:45 Periods Tutorial:0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Tom Denton, "**Automobile Electrical and Electronic Systems**", Arnold Publishers, V Edition 2017.*
2	*William B Ribbens, "**Understanding Automotive Electronics**", VIII Edition, Newness Publishers, 2017*

REFERENCES:

1	*V A W Hillier "***Fundamentals of Automotive Electronics***", OUP Oxford, II Edition 2012.*
2	*Ronald K Jurgen, "***Automotive Electronic Handbook**", *McGraw Hill, II Edition, 1999.*
3	*Robert Bosch, "***Automotive Electrics and Automotive Electronics***", Springer, V Edition,2014.*
4	*Bogdan M. Wilamowski, J. David Irwin "***The Industrial Electronics Handbook***", CRC Press , II edition,2011*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Perceive the electronics involved in automotive systems	K2
CO2	Outline the fundamentals involved in ignition systems	K2
CO3	Choose appropriate sensors for automobiles based on applications	K3
CO4	Implement simple and safe control systems in automobiles	K5
CO5	Analyze the safety issues that occur in automotive systems	K4

ELECTIVE - IV

25WPE7E1	DESIGN OF ELECTRIC VEHICLES CHARGING SYSTEMS	SEMESTER VII

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To demonstrate the concepts of power converters in charging Electric Vehicles and power factor correction techniques.	
UNIT – I	**CHARGING STATIONS AND STANDARDS**	**(9 Periods)**
Introduction-Charging technologies- Conductive charging, EV charging infrastructure, international standards and regulations - Inductive charging, need for inductive charging of EV, Modes and operating principle, Static and dynamic charging, Bidirectional power flow, International standards and regulations.		
UNIT – II	**POWER ELECTRONICS FOR EV CHARGING**	**(9 Periods)**
Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit - Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter.		
UNIT – III	**EV CHARGING WITH RENEWABLE AND STORAGE SYSTEMS**	**(9 Periods)**
Introduction- - EV charger topologies, EV charging/discharging strategies - Integration of EV charging-home solar PV system, Operation modes of EVC-HSP system, Control strategy of EVC-HSP system - fast-charging infrastructure with solar PV and energy storage.		
UNIT – IV	**WIRELESS POWER TRANSFER**	**(9 Periods)**
Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs -Charging Modes in EVs - Benefits of WPT. - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954, IEC 61980. ISO 19363.		
UNIT – V	**POWER QUALITY ISSUES IN CHARGING SYSTEM**	**(9 Periods)**
Need for power factor correction- Boost converter for Power Factor Correction, Sizing the inductor- Active front end converter - Average current in the rectifier and calculation of power losses- Analysis of Harmonics due to charging System.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Miao Wang, Ran Zhang and Xuemin (Sherman) Shen, **"Mobile Electric Vehicles: Online Charging and Discharging"**, Springer, I Edition, 2016.*
2	*Alicia Triviño-Cabrera, José M. González-González and José A. Aguado, **"Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach"**, Springer, I Edition, 2020.*

REFERENCES:

1	*Akash Kumar Bhoi, Sanjeevikumar Padmanaban and Jens Bo Holm-Nielsen,* ***"Electric Vehicles: Modern Technologies and Trends"****, Springer, I Edition, 2021.*
2	*Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg,* ***"Cable-Based and Wireless Charging Systems for Electric Vehicles: Technology, Control, Management and Grid Integration"****, IET Publishing, I Edition, 2021.*
3	*James D. Halderman,* ***"Electric and Hybrid Electric Vehicles"****, Pearson, I Edition, 2022.*
4	*Ali Emadi,* ***"Handbook of Automotive Power Electronics and Motor Drives"****, CRC Press, I Edition, 2005.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Illustrate various charging techniques and know charging standards and regulations.	K2
CO2	Demonstrate the working of DC-DC converters used for charging systems and principles	K2
CO3	Summarize the advantages of renewable system-based charging systems	K5
CO4	Demonstrate the principles of wireless power transfer.	K2
CO5	Analyze the standards for wireless charging.	K4

25WPE7E2	TESTING OF ELECTRIC VEHICLES	SEMESTER VII

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To know various standardization procedures, testing procedures for EV & HEV components, functional safety and EMC, effect of EMC in EVs, effect of EMI in motor drives and in DC-DC converter system.	
UNIT – I	**EV STANDARDIZATION**	**(9 Periods)**
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 Periods)**
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 Periods)**
Functional safety life cycle - Fault tree analysis - Hazard and risk assessment - re 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 Periods)**
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 SYSTEM**	**(9 Periods)**
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.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Li Zhai,* ***"Electromagnetic Compatibility of Electric Vehicles"****, Springer, I Edition, 2021.*
2	*Ali Emadi,* ***"Handbook of Automotive Power Electronics and Motor Drives"****, CRC Press, II Edition, 2017.*

REFERENCES:

1	*Kai Borgeest,* ***"EMC and Functional Safety of Automotive Electronics"****, IET Publishing, I Edition, 2018.*
2	*Beate Müller and Gereon Meyer (Eds.),* ***"Electric Vehicle Systems Architecture and Standardization Needs"****, Springer, I Edition, 2015.*
3	*Bruce Archambeault, Colin Brench and Omar M. Ramahi,* ***"EMI / EMC Computational Modeling Handbook"****, Springer, II Edition, 2012.*
4	*Vijayakumar Gali, Luciane Neves Canha, Mariana Resener, Bibiana Ferraz, Madisa V.G. Varaprasad****, " Advanced Technologies in Electric Vehicles: Challenges and Future Research Developments", Acad****emic Press (Elsevier), 1st Edition, 2024.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe the status and other details of standardization of EVs	K2
CO2	Illustrate the testing protocols for EVs and HEV components	K3
CO3	Analyze the safety cycle and need for functions safety for EVs	K4
CO4	Analyze the problems related with EMC for EV components.	K4
CO5	Evaluate the EMI in the motor drive and DC-DC converter system.	K5

25WPE7E3	GRID INTEGRATION OF ELECTRIC VEHICLES	SEMESTER VII

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To gain overall idea about Grid integration of Electric vehicles, their effects and remedies.	
UNIT – I	**STATUS OF V2G**	**(9 Periods)**
Defining 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 Periods)**
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 Periods)**
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 Periods)**
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 Periods)**
Introduction-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.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOKS:

1	*Ali Emadi, **"Advanced Electric Drive Vehicles"**, CRC Press, II Edition, 2017.*
2	*Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, **"Plug-in Electric Vehicles in Smart Grids: Charging Strategies"**, Springer, I Edition, 2015.*

REFERENCES:

1	*Nand Kishor and Jesus Fraile-Ardanuy,* ***"ICT for Electric Vehicle Integration with the Smart Grid"****, IET Publishing, I Edition, 2020.*
2	*Lance Noel, Gerardo Zarazua de Rubens, Johannes Kester and Benjamin K. Sovacool,* ***"Vehicle-to-Grid: A Sociotechnical Transition Beyond Electric Mobility"****, Palgrave Macmillan, I Edition, 2019.*
3	*Chris Mi, M. Abul Masrur and David Wenzhong Gao,* ***"Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives"****, Wiley, II Edition, 2017.*
4	*Junwei Lu and Jahangir Hossain,* ***"Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid"****, IET Publishing, I Edition, 2015.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concepts related with V2G.	K2
CO2	Study the grid connection of 3 phase Q inverter	K1
CO3	Explain technical, economics. business, regulatory & political challenges related with V2G	K3
CO4	Demonstrate the impact of EV and V2G on smart grid and renewable energy system	K4
CO5	Explain the concept of grid integration and management of EVs.	K5

25WPE7E4	INTELLIGENT CONTROL OF ELECTRIC VEHICLES	SEMESTER VII

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To design and derive the mathematical model of a BLDC motor and its characteristics and to learn the different control schemes for BLDC motor and implement in Fuzzy/FPGA.	
UNIT – I	**ANALYSIS OF BLDC MOTOR**	**(9 Periods)**
Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristic Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients.		
UNIT – II	**CONTROLLERS FOR BLDC MOTOR**	**(9 Periods)**
Introduction -PID Control Principle, Anti-windup Controller, Intelligent Controller – Fuzzy Logic- Control applied to BLDC motor.		
UNIT – III	**FPGA ARCHITECTURE**	**(9 Periods)**
Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7.		
UNIT – IV	**FPGA PROGRAMMING**	**(9 Periods)**
VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs: arithmetic, sorting, PWM generation, Speed detection, Speed Control.		
UNIT – V	**REAL TIME IMPLEMENTATION**	**(9 Periods)**
Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of BLDC motor using FPGA- Introduction to Battery Management System in EV.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total:45 Periods**		

TEXT BOOKS:

1	*John G. Hayes and G. Abas Goodarzi,* ***"Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles"****, Wiley, I Edition, 2018.*
2	*Jayaram Bhasker,* ***"A VHDL Primer"****, Pearson Education, III Edition, 2015.*

REFERENCES:

1	*Iqbal Hussain,* ***"Electric and Hybrid Electric Vehicles: Design Fundamentals"****, CRC Press, III Edition, 2021.*
2	*Wei Liu,* ***"Hybrid Electric Vehicle System Modeling and Control"****, Wiley, II Edition, 2017.*
3	*Chang-liang Xia,* ***"Permanent Magnet Brushless DC Motor Drives and Controls"****, Wiley, I Edition, 2012.*
4	*M. N. Cirstea, A. Dinu, J. G. Khor and M. McCormick,* ***"Neural and Fuzzy Logic Control of Drives and Power Systems"****, Newnes, I Edition, 2002.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Interpret the mathematical model of a BLDC motor and discuss its characteristics	K2
CO2	Demonstrate the different controller actions applied to the BLDC motor.	K3
CO3	Review the basics of fuzzy logic systems.	K2
CO4	Develop the control of EVs using FPGA.	K3
CO5	Devise fuzzy logic control scheme for BLDC motors.	K4

25WPE7E5	HYBRID ELECTRIC AND FUEL CELL VEHICLES		SEMESTER VII			
PRE REQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objectives	To learn the mechanics, operation and performance of hybrid electric and fuel cell vehicles.					
UNIT – I	**HYBRID ELECTRIC VEHICLES**		**(9 Periods)**			
Concept of Hybrid Electric Drive Trains- Architectures of Hybrid Electric Drive Trains- Series/Parallel - Torque-Coupling Parallel Hybrid Electric Drive Trains - Speed-Coupling Parallel Hybrid Electric Drive Trains-Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains.						
UNIT – II	**ELECTRIC PROPULSION SYSTEMS**		**(9 Periods)**			
Principle and Operation: DC series motor drives- Induction Motor Drives - Permanent Magnet Brushless DC Motor Drives -Permanent Magnet Synchronous Motor Drives - Switched Reluctance Motor Drives.						
UNIT – III	**SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN**		**(9 Periods)**			
Operation Patterns - Control Strategies - Sizing of the Major Components - Design of Traction Motor, Gear Ratio, Acceleration Performance, Gradeability, Engine / Generator Size, Power and Energy Capacity.						
UNIT – IV	**MILD HYBRID ELECTRIC DRIVE TRAIN DESIGN**		**(9 Periods)**			
Energy Consumed in Braking and Transmission- Parallel Mild Hybrid Electric Drive Train- Series–Parallel Mild Hybrid Electric Drive Train- Configuration- Operating Modes and Control- Control Strategy.						
UNIT – V	**FUEL CELL VEHICLES**		**(9 Periods)**			
Operating Principles of Fuel Cells-Electrode Potential and Current–Voltage Curve-Fuel and Oxidant Consumption-Fuel Cell System Characteristics-Fuel Cell Technologies-Fuel Supply-Non-Hydrogen Fuel Cells.						
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

TEXT BOOK :

1	*Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi,* **"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**", *CRC Press, 2018.*
2	*Iqbal Husain,* ***"Electric and Hybrid Vehicles, Design Fundamentals"****, III Edition, CRC Press, 2021*

REFERENCES :

1	*Ali Emadi, Mehrdad Ehsani, John M. Miller,* ***"Vehicular Electric Power Systems",*** *Special Indian Edition, Marcel Dekker, Inc 2003, I Edition.*
2	*C.C. Chan and K.T. Chau, '****Modern Electric Vehicle Technology',*** *OXFORD University Press, 2001, I Edition.*
3	*Wie Liu,* ***"Hybrid Electric Vehicle System Modeling and Control"****, Second Edition, John Wiley & Sons, 2017, II Edition.*
4	*Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy,* ***"Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK****", Wiley, I Edition, 2021.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Describe the concepts related to EV, and HEV and compare the same with internal combustion engine vehicles	**K2**
CO2	Relate the electric drives used in HEV	**K2**
CO3	Analyze and design the hybrid electric train components	**K4**
CO4	Examine the concepts related to series/parallel hybrid electric drive train	**K4**
CO5	Demonstrate the architecture of fuel cell vehicles.	**K2**