GOVERNMENT COLLEGE OF ENGINEERING
SALEM - 636 011

(An Autonomous Institution Affiliated to Anna University, Chennai)

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

B.E. (ELECTRICAL AND ELECTRONICS ENGINEERING)
[WORKING PROFESSIONALS]

REGULATIONS - 2025

CURRICULUM AND SYLLABUS

(For Candidates Admitted during 2025 - 2026)

VISION OF THE DEPARTMENT

- To make ethically and emotionally strong Electrical Engineers of high caliber capable of meeting the national and global technological challenges for the well-being of Society.

MISSION OF THE DEPARTMENT

- To Impart state-of-the-art Knowledge in Electrical Science and Technology through under-graduate and graduate programmes.
- To develop the Electrical Engineering Department as a Centre of Excellence in Power Electronics and Industrial Drives.
- To provide Knowledge base and Consultancy services to the society at large and in particular for the upliftment and well-being of the rural and tribal communities.

VISION AND MISSION OF THE INSTITUTION

Vision

- We envision our students as excellent Engineers not only in the field of Science and Technology, but also in good citizenship and discipline.
- Our commitment lies in producing comprehensive knowledge seekers and humane individuals, capable of building a strong and developed nation.

Mission

- To impart update technical education and knowledge.
- To groom our young students to become professionally and morally sound engineers.
- To teach global standards in production and value-based living through honest and scientific approach.

GOVERNMENT COLLEGE OF ENGINEERING, SALEM
B.E. (ELECTRICAL AND ELECTRONICS ENGINEERING) [WORKING PROFESSIONALS]
CURRICULUM AND SYLLABUS REGULATIONS – 2025

SEMESTER - I										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTMA101	Mathematics-I	BS	3	0	0	3	40	60	100
2.	25PTEE101	Electric Circuit Analysis	PC	2	1	0	3	40	60	100
3.	25PTEE102	Electromagnetic Theory	PC	2	1	0	3	40	60	100
4.	25PTEE103	DC Machines and Transformers	PC	2	1	0	3	40	60	100
5.	25PTEE104	Electron Devices and Circuits	PC	3	0	0	3	40	60	100
		TOTAL					**15**			**500**
SEMESTER – II										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTMA201	Mathematics-II	BS	3	0	0	3	40	60	100
2.	25PTEE201	Synchronous and Induction Machines	PC	2	1	0	3	40	60	100
3.	25PTEE202	Measurements and Instrumentation	PC	3	0	0	3	40	60	100
4.	25PTEE203	Analog and Digital Integrated Circuits	PC	3	0	0	3	40	60	100
PRACTICAL										
5.	25PTEE204	Electrical Machines Laboratory	PC	0	0	3	1.5	60	40	100
		TOTAL					**13.5**			**500**
SEMESTER – III										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTEE301	Control Systems	PC	2	1	0	3	40	60	100
2.	25PTEE302	Power Electronics	PC	3	0	0	3	40	60	100
3.	25PTEE303	Microprocessors and Microcontrollers	PC	3	0	0	3	40	60	100
4.	25PTCS301	C Programming for Electrical Engineers	ES	3	0	0	3	40	60	100
PRACTICAL										
5.	25PTEE304	Microprocessor and Microcontroller Laboratory	PC	0	0	2	1	60	40	100
		TOTAL					**13**			**500**

SEMESTER – IV										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTEE401	Power Generation, Transmission, and Distribution System	PC	2	1	0	3	40	60	100
2.	25PTEE402	Electrical Drives and Control	PC	3	0	0	3	40	60	100
3.	25PTEE403	Industrial Management and Economics	PC	3	0	0	3	40	60	100
4.	25PTCY101	Environmental Science and Engineering	BS	3	0	0	3	40	60	100
PRACTICAL										
5.	25PTEE404	Power Electronics and Energy Systems Laboratory	PC	0	0	3	1.5	60	40	100
		TOTAL					**13.5**			**500**

SEMESTER – V										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTEE501	Power System Analysis and Stability	PC	2	1	0	3	40	60	100
2.	25PTEE502	Power System Protection and Switchgear	PC	3	0	0	3	40	60	100
3.	25PTEEPE1x	Professional Elective-I	PE	3	0	0	3	40	60	100
4.	25PTEEPE2x	Professional Elective-II	PE	3	0	0	3	40	60	100
5.	25PTHS501	Universal Human Values	HS	2	1	0	3	40	60	100
		TOTAL					**15**			**500**

SEMESTER – VI										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTEE601	Solar and Wind Energy Conversion Systems	PC	3	0	0	3	40	60	100
2.	25PTEE602	Smart Grid Technologies	PC	3	0	0	3	40	60	100
3.	25PTEE603	Special Electrical Machines	PC	3	0	0	3	40	60	100
4.	25PTEEPE3x	Professional Elective-III	PE	3	0	0	3	40	60	100
5.	25PTEEPE4x	Professional Elective-IV	PE	3	0	0	3	40	60	100
		TOTAL					**15**			**500**

SEMESTER – VII										
S No	**Course Code**	**Course Title**	**Category**	**Hours per Week**			**Credit**	**Maximum Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1.	25PTEE701	High Voltage Engineering	PC	3	0	0	3	40	60	100
2.	25PTEEPE5x	Professional Elective-V	PE	3	0	0	3	40	60	100
3.	25PTEEPE6x	Professional Elective-VI	PE	3	0	0	3	40	60	100
PRACTICAL										
4.	25PTEE702	Project Work	EEC	0	0	6	3	120	80	200
TOTAL							**12**			**500**
GRAND TOTAL							**97**			

B.E. (Electrical and Electronics Engineering) [Working Professionals]
PROFESSIONAL ELECTIVES COURSES

Sl. No.	Course Code	Course Title	Category	Hours per Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
PROFESSIONAL ELECTIVE – I (V SEMESTER)										
1	25PTEEPE11	Network Analysis and Synthesis	PE	3	0	0	3	40	60	100
2	25PTEEPE12	Advanced Control Systems	PE	3	0	0	3	40	60	100
3	25PTEEPE13	Discrete Control Systems	PE	3	0	0	3	40	60	100
4	25PTEEPE14	Biomedical Instrumentation	PE	3	0	0	3	40	60	100
5	25PTEEPE15	Biology for Electrical Engineers	PE	3	0	0	3	40	60	100
6	25PTEEPE16	Adaptive Control	PE	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVE – II (V SEMESTER)										
1	25PTEEPE21	HVDC Transmission Systems	PE	3	0	0	3	40	60	100
2	25PTEEPE22	EHVAC Transmission Systems	PE	3	0	0	3	40	60	100
3	25PTEEPE23	Flexible AC Transmission Systems	PE	3	0	0	3	40	60	100
4	25PTEEPE24	Power System Operation and Control	PE	3	0	0	3	40	60	100
5	25PTEEPE25	Underground Cable Engineering	PE	3	0	0	3	40	60	100
6	25PTEEPE26	Power System State Estimation and Security Control	PE	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVE – III (VI SEMESTER)										
1	25PTEEPE31	Digital Signal Processing	PE	3	0	0	3	40	60	100
2	25PTEEPE32	Embedded System Design	PE	3	0	0	3	40	60	100
3	25PTEEPE33	Artificial Intelligence and Computer Vision	PE	3	0	0	3	40	60	100
4	25PTEEPE34	Soft Computing Techniques	PE	3	0	0	3	40	60	100
5	25PTEEPE35	Internet of Things for Electrical System	PE	3	0	0	3	40	60	100
6	25PTEEPE36	MEMS and NEMS	PE	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVE – IV (VI SEMESTER)										
1	25PTEEPE41	Power System Transients	PE	3	0	0	3	40	60	100
2	25PTEEPE42	Power Quality	PE	3	0	0	3	40	60	100
3	25PTEEPE43	Distributed Generation and Micro Grid	PE	3	0	0	3	40	60	100
4	25PTEEPE44	Restructured Power System	PE	3	0	0	3	40	60	100
5	25PTEEPE45	Control and Integration of Renewable Energy Sources	PE	3	0	0	3	40	60	100
6	25PTEEPE46	Design and Modelling of Renewable Energy Systems	PE	3	0	0	3	40	60	100

PROFESSIONAL ELECTIVE – V (VII SEMESTER)										
1	25PTEEPE51	Utilization of Electrical Energy	PE	3	0	0	3	40	60	100
2	25PTEEPE52	Electrical Energy Conservation and Auditing	PE	3	0	0	3	40	60	100
3	25PTEEPE53	Electrical Wiring, Estimation and Costing	PE	3	0	0	3	40	60	100
4	25PTEEPE54	Traction Engineering	PE	3	0	0	3	40	60	100
5	25PTEEPE55	Energy Storage Systems and Applications	PE	3	0	0	3	40	60	100
6	25PTEEPE56	SMPS and UPS	PE	3	0	0	3	40	60	100
PROFESSIONAL ELECTIVE – VI (VII SEMESTER)										
1	25PTEEPE61	Energy Management System and SCADA	PE	3	0	0	3	40	60	100
2	25PTEEPE62	Industrial Electrical Systems	PE	3	0	0	3	40	60	100
3	25PTEEPE63	Electric Vehicles and Control	PE	3	0	0	3	40	60	100
4	25PTEEPE64	Embedded Control for Electrical Drives	PE	3	0	0	3	40	60	100
5	25PTEEPE65	Grid Integration of Electric Vehicles	PE	3	0	0	3	40	60	100
6	25PTEEPE66	Embedded System for Automotive Applications	PE	3	0	0	3	40	60	100

SUMMARY OF CREDITS

Sl. No	Course Components	Credits per Semester							Total Credits
		I	II	III	IV	V	VI	VII	
1.	Humanities and Social Science (HS)					3			**3**
2.	Basic Sciences (BS)	3	3		3				**9**
3.	Engineering Sciences (ES)			3					**3**
4.	Professional Core (PC)	12	10.5	10	10.5	6	9	3	**61**
5.	Professional Electives (PE)					6	6	6	**18**
6.	Open Electives (OE)								
7.	Employment Enhancement Course (EEC)							3	**3**
8.	Mandatory / Management / Non-Credit Course (MC/HSMC)								
Total Credits		**15**	**13.5**	**13**	**13.5**	**15**	**15**	**12**	**97**

25PTMA101	MATHEMATICS – I (Common to Part Time B.E. - CIVIL, ECE, EEE & MECH Branches)	SEMESTER	I

PREREQUISITES	CATEGORY	BS	Credit		3
Basic 12th level knowledge of ODE, PDE, Vector algebra and Complex Analysis.	Hours / Week	L	T	P	TH
		3	0	0	3

Course Objectives:

1.	To make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.
2.	To make the student to understand the techniques in solving partial differential equations that model engineering problems.
3.	To acquaint the student with the concepts of vector calculus needed for solving engineering problems.
4.	To understand the concept of analytic functions.
5.	To obtain the knowledge of complex integration

UNIT I	ORDINARY DIFFERENTIAL EQUATIONS	9	0	0	9

Higher order linear differential equations with constant coefficients – Method of variation of parameters – Cauchy’s and Legendre’s linear equations.

UNIT II	PARTIAL DIFFERENTIAL EQUATIONS	9	0	0	9

Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions – Lagrange’s linear equation – Homogeneous Linear partial differential equations of second order with constant coefficients.

UNIT III	VECTOR CALCULUS	9	0	0	9

Gradient, divergence and curl – Directional derivative – Irrotational and solenoidal vector fields – Vector integration – Statement of Gauss divergence theorem and Stokes theorem – Simple applications involving cubes and rectangular parallelopipeds.

UNIT IV	ANALYTIC FUNCTIONS	9	0	0	9

Functions of a complex variable – Analytic functions – Necessary conditions, Cauchy – Riemann equation and sufficient conditions (excluding proofs) – Properties of analytic function – Harmonic conjugate – construction of analytic functions – Conformal mapping: $w = z + c,\ cz,\ \frac{1}{z}$ and bilinear transformation.

UNIT V	COMPLEX INTEGRATION	9	0	0	9

Complex integration – Statement and applications of Cauchy’s integral theorem and Cauchy’s integral formula – Taylor’s and Laurent’s expansions – Singular points – residues – Residue theorem – Application of residue theorem to evaluate real integrals over semi-circular contours (excluding poles on boundaries).

Total (45L + 0T) = 45 Periods

Text Books:

1.	B.S. Grewal, “Higher Engineering Mathematics”, 43rd Edition, Khanna Publications, Delhi, 2015.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy, “Engineering Mathematics (For I year B. E, B. Tech)”, Ninth Edition, S. Chand & Co. Ltd., New Delhi, 2010.

Reference Books:

1.	James Stewart, “Calculus with Early Transcendental Functions”, Cengage Learning, New Delhi, 2008.
2.	T.Veerarajan, “Engineering Mathematics (For semester I and II)”, 5th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
3.	Erwin Kreyszig, “Advanced Engineering Mathematics”, 7th Edition, Wiley India, 2007.

4.	R.K. Jain and S.R.K. Iyengar, "Advanced Engineering Mathematics", 3rd Edition, Narosa Publishing House Pvt. Ltd., 2007.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Find the techniques of solving ordinary differential equations that arise in engineering problems.	L3: Applying
CO2	:	Find the techniques of solving partial differential equations that arise in engineering problems.	L3: Applying
CO3	:	Apply the concept of vector calculus and vector integration.	L3: Applying
CO4	:	Understand analytic function and its properties.	L2: Understanding
CO5	:	Evaluate various integrals by using Cauchy's residue theorem.	L5: Evaluating

25PTEE101	ELECTRIC CIRCUIT ANALYSIS		SEMESTER			I
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Mathematics and Physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To study the fundamentals of the concept of circuit elements, the basic laws of networks.
2.	To learn and analyse the AC single phase and three phase circuits.
3.	To understand the Laplace Transforms in the context of circuit representations.
4.	To analyse the two-port network and its parameters.

UNIT I	**ANALYSIS METHODS AND NETWORK THEOREMS**	**6**	**3**	**0**	**9**

Node and Mesh Analysis. Analysis with dependent current and voltage sources. Concept of duality and dual networks. Applications of: Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem.

UNIT II	**SOLUTION OF FIRST AND SECOND ORDER NETWORKS**	**6**	**3**	**0**	**9**

Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

UNIT III	**SINUSOIDAL STEADY STATE ANALYSIS**	**6**	**3**	**0**	**9**

Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Single Phase circuits, Three-phase circuits – Balanced and Unbalanced Circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

UNIT IV	**ELECTRIC CIRCUIT ANALYSIS USING LAPLACE TRANSFORMS**	**6**	**3**	**0**	**9**

Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots)

UNIT V	**RESONANCE AND TWO PORT NETWORK FUNCTIONS**	**6**	**3**	**0**	**9**

Series and Parallel Resonance and analysis. Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

Total (30L+15T) = 45 Periods

Text Books:

1.	M Nahvi and I.A.Edminister "Electric Circuits"; Schaum's outline series, McGraw Hill, 5th Edition, 2019.
2.	Charles K. Alexander, Mathew N.O. Sadiku, "Fundamentals of Electric Circuits", Fifth Edition, McGraw Hill, 2019.
3.	James W. Nilsson and Susan A. Riedel ," Electric circuits ", Pearson Education, Inc, 11th Edition, 2019.

Reference Books:

1.	William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits

	Analysis", McGraw Hill publishers, New Delhi, 9th Edition, 2020.
2.	Sudhakar. A, Shyammohan. S.P "Circuits and Networks-Analysis and Synthesis" McGraw Hill, 5th Edition, 2017.
3.	M. E. Van Valkenburg and T.S. Rathore, "Network Analysis", Revised 3rd Edition, Pearson Education, 2019.
4.	D. Roy Choudhury, "Networks and Systems", New Age International Publishers, Second Edition, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Solve the electrical network using mesh, nodal analysis and applying network theorems.	L3: Applying
CO2	:	Solve the first order and second order differential equations for series and parallel circuits and analyse its steady state and transient response.	L3: Applying
CO3	:	Analyze the steady state response for AC sinusoidal input and and basic concepts of resonance and coupled circuits.	L4: Analyzing
CO4	:	Analyse the electrical circuit using Laplace transforms	L4: Analyzing
CO5	:	Understand the two port networks and its parameters for electric circuit analysis.	L2: Understanding

25PTEE102	ELECTROMAGNETIC THEORY		SEMESTER			I
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Basic Electrical and Electronics Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

To impart knowledge on the basic concepts of vectors, coordinate systems, static and dynamic electric and magnetic fields and apply maxwells equations for various engineering applications involving electromagnetic waves.

UNIT I	ELECTROSTATICS – I	6	3	0	9

Vector fields: Components of a vector and Classification of vector fields - Coordinate Systems and transformation – Gradient, Divergence, Curl – theorems and applications - Coulomb's Law – Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications.

UNIT II	ELECTROSTATICS – II	6	3	0	9

Electric flux density – Electric potential – Electric dipole – Electric field in free space, conductors, dielectrics, - Dielectric polarization- Dielectric strength- Electric field in multiple dielectrics-– Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications.

UNIT III	MAGNETOSTATICS	6	3	0	9

Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetic scalar and vector potential - Magnetic force, Torque and Moment - Magnetization, Magnetic field in multiple media – Boundary conditions, Poisson's Equation, Inductance, Energy density, Applications.

UNIT IV	ELECTRODYNAMIC FIELDS	6	3	0	9

. Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Time-Varying Potentials - Time-Harmonic Fields - Relation between field theory and circuit theory

UNIT V	ELECTROMAGNETIC WAVES	6	3	0	9

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.

Total (30L+15T) = 45 Periods

Text Books:

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.
3. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.

Reference Books:

1. V.V.Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993.
2. J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers.

3.	Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), McGraw Hill, 2010.
4.	S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2012.
5.	K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Eighth Reprint : 2015.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamental concept, laws and theorem of electric and magnetic fields.	L1: Remembering
CO2	:	Associate the concepts in electrostatic fields and magnetic fields.	L2: Understanding
CO3	:	Analyze the Electric and magnetic Field in material space.	L4: Analysing
CO4	:	Apply the boundary conditions to the applications in electrostatic fields and magnetostatic fields.	L3: Applying
CO5	:	Assess the knowledge of electromagnetic waves and characterizing parameters.	L4: Analysing

25PTEE103	DC MACHINES AND TRANSFORMERS		SEMESTER			I
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To understand the concepts of electromechanical energy conversion and to gain the knowledge on single and multiply-excited magnetic systems.
2.	To gain the knowledge on construction and principles of operation of DC machines and transformers.
3.	To analyze the performance characteristics of different types of DC machines and transformers.
4.	To appreciate the applications of DC machines and transformers.
5.	To analyze the performance of DC machines and transformers by conducting various tests.

Unit I	**ELECTROMECHANICAL ENERGY CONVERSION**	**6**	**3**	**0**	**9**

Magnetic circuits – Magnetically induced EMF and force – AC operation of magnetic circuits – Energy in magnetic systems – Field energy & mechanical force – Single and Multiply-excited magnetic field systems.

Unit II	**DC GENERATORS**	**6**	**3**	**0**	**9**

Constructional features of DC machine – Principle of operation of DC generator – EMF equation – Types of excitation – No load and load characteristics of DC generators – Commutation - Armature reaction – Parallel operation of DC generators - Applications.

Unit III	**DC MOTORS**	**6**	**3**	**0**	**9**

Principle of operation of DC motors - Back EMF – Torque equation – Types of DC motors – Speed and Torque characteristics of DC motors – Starting of DC motors: 3- point starter, 4- point starter – Speed control of shunt and series motor: Field current control and Armature voltage control – Applications.

Unit IV	**TRANSFORMERS**	**6**	**3**	**0**	**9**

Constructional features of single-phase transformers–Principle of operation - EMF equation –ideal transformer characteristics - Practical Transformer working on No- load and Load with phasor diagram – Equivalent circuit – Regulation – Parallel operation - Autotransformers - Three phase transformer connections.

Unit V	**TESTING OF DC MACHINES AND TRANSFORMERS**	**6**	**3**	**0**	**9**

Losses and efficiency – Condition for maximum efficiency – Testing of DC machines: Swinburne's test and Hopkinson's test - Testing of transformers: open circuit and short circuit tests, Sumpner's test – All day efficiency.

Total (30L+15T)= 45 Periods

Text Books:

1.	D.P. Kothari, I.J. Nagrath, "Electric Machines", Fifth Edition, McGraw-Hill Education, New York, 2017.
2.	Dr. P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, New Delhi, 2nd Edition, 2021.

Reference Books:

1.	B.L. Theraja& A.K. Theraja, "Electrical Technology", Vol.II, S.Chand & Company Ltd., New Delhi, 2015.
2.	A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, "Electric Machinery", McGraw Hill Education Ltd, 6th Edition, 2017.
3.	K. Murugesh Kumar, "DC Machines and Transformers", Vikas Publishing House Pvt. Ltd., Second Edition, 2004.

E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recite the concepts of electromechanical energy conversion principles for single and multiply excited magnetic field system.	L1: Remembering
CO2	:	Explain the construction and working principal of DC machines and transformers.	L2: Understanding
CO3	:	Evaluate the performance characteristics of DC machines and transformers.	L5: Evaluating
CO4	:	Compute various performance parameters of DC machines, by conducting suitable tests.	L3: Applying
CO5	:	Predetermine efficiency and regulation parameters of Transformer by conducting suitable test.	L3: Applying

25PTEE104	ELECTRON DEVICES AND CIRCUITS			SEMESTER		I
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To understand the characteristics of diodes.
2. To understand the characteristics of transistors.
3. To design amplifier circuits
4. To design the oscillator circuits.

UNIT I	DIODES	9	0	0	9

Structure – Equilibrium conditions – Energy Band Concepts – Zero bias – Forward Bias – Reverse bias – Junction capacitances – one sided and Non- uniformly doped junctions – Ideal PN junction current, P-N junction diode, V-I characteristics of a diode, review of half-wave and full-wave rectifiers, Zener diodes, voltage regulator using zener diode, clamping and clipping circuits.

UNIT II	TRANSISTORS	9	0	0	9

Physical behaviour of a BJT – Ebers - Moll model. Modes of transistor operation - Common base, common emitter and common collector configurations, Input and output characteristics, Early effect, regions of operation. AC and DC load lines - Need for stability of Q-Point. Bias stability – fixed bias, collector to base bias, self bias. Junction field effect transistor – structure, JFET structure and MOSFET characteristics and characteristics -UJT- structure and characteristics.

UNIT III	SMALL SIGNAL AMPLIFIER CIRCUITS	9	0	0	9

Single stage BJT and FET amplifiers, Analysis at low, medium and high frequencies – BJT and FET Differential amplifier, Differential and Common mode gain with resistive load and active load, CMRR - Cascode and Darlington Amplifiers.

UNIT IV	LARGE SIGNAL AMPLIFIER CIRCIUTS	9	0	0	9

Power amplifiers– Classification, Single ended and Push-pull Configuration, Power dissipation, Output power and Conversion efficiency, Complementary symmetry power amplifiers, Class AB operation, Class C and Class D amplifiers, thermal considerations.

UNIT V	FEEDBACK AMPLIFIERS AND OSCILLATORS	9	0	0	9

Advantages of negative feedback – voltage / current, series, Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

Total (45L+0T)= 45 Periods

Text Books:

1. Millman J, Halkias C, SatyaBrata JIT, “Electronic Devices & Circuits”, Tata McGraw-Hill, New Delhi, 2010.
2. David A. Bell, “Electronic Devices and Circuits”, New Delhi: Oxford University Press, 5th Edition, 2008.
3. Boylestead L R, Nashelsky L, “Electronic Devices and Circuit Theory”, Pearson Education, New Delhi, 2009.

Reference Books:

1. Rashid, “Micro Electronic Circuits” Thomson publications, 1999.
2. Donald L.Schilling and Charles Belove, “Electronic Circuits”, 3 Edition, Tata McGraw Hill, 2010.

3.	Adel Sedra, Kenneth.C Smith, "Microelectronics Circuits", Oxford University Press, New Delhi, 2010
E-Reference	
1.	https://electronicsforu.com/resources/electronic-devices-and-circuit-theory
2.	https://nptel.ac.in/courses/117103063/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand overview of semiconductor devices.	L2: Understanding
CO2	:	Recognize the fundamentals and characteristics of BJT	L1: Remembering
CO3	:	Analyze the fundamentals and characteristics of FET and UJT	L2: Understanding
CO4	:	Design and analyze the amplifiers	L4: Analysing
CO5	:	Design and analyze the differential amplifiers	L4: Analysing

25PTMA201	**MATHEMATICS – II** **(Common to Part-Time B.E - CIVIL, ECE, EEE & MECH branches)**			**SEMESTER**			**II**
PREREQUISITES			**CATEGORY**	**BS**	**Credit**		**3**
Basic 12th level knowledge of Differential Calculus, Integral Calculus and ODE.			**Hours / Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the concept of Fourier series.
2.	To understand the application of Fourier analysis in solving boundary value problems.
3.	To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
4.	To familiarize with Fourier, transform of a function and its sine and cosine transforms.
5.	To gain the skills to form difference equations and find its solution by using Z-transform method.

UNIT I	**FOURIER SERIES**	**9**	**0**	**0**	**9**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity.

UNIT II	**BOUNDARY VALUE PROBLEMS**	**9**	**0**	**0**	**9**

Classification of second order quasi linear partial differential equations – Solutions of one-dimensional wave equation – One dimensional heat equation – Steady state solution of two-dimensional heat equation for infinite plates (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

UNIT III	**LAPLACE TRANSFORM**	**9**	**0**	**0**	**9**

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform-statement and application of convolution theorem.

UNIT IV	**FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Statement of Fourier integral theorem – Fourier transforms pair – Sine and Cosine transforms Properties – Transforms of simple functions – Parseval's Identity.

UNIT V	**Z -TRANSFORM AND DIFFERENCE EQUATIONS**	**9**	**0**	**0**	**9**

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem - Solution of difference equations using Z – transform technique.

Total (45L + 0T) = 45 Periods

Text Books:

1.	T. Veerarajan, "Engineering Mathematics (For Semester III)", 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2.	P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company Ltd., New Delhi, 1996.

Reference Books:

1.	B.S. Grewal, "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
2.	Wylie C. Ray and C.Barrett Louis, "Advanced Engineering Mathematics", Sixth Edition, McGraw-Hill, Inc., New York, 1995.
3.	L.A. Andrews and B.K Shivamoggi, "Integral Transforms for Engineers and Applied Mathematicians", MacMillan, New York, 1988.
4.	S. Narayanan, T.K. Manicavachagom Pillai, and G. Ramaniah, "Advanced Mathematics for Engineering Students", Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002.

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Acquire the knowledge about Fourier series.	L2: Understanding
CO2	:	Appreciate the physical significance of Fourier series techniques in solving one- and two-dimensional heat flow problems and one-dimensional wave equations.	L3: Applying
CO3	:	Apply the knowledge of Laplace transforms method to solve second order differential equations.	L3: Applying
CO4	:	Apply the knowledge of Fourier transform in engineering problems.	L3: Applying
CO5	:	Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.	L3: Applying

25PTEE201	SYNCHRONOUS AND INDUCTION MACHINES			SEMESTER		II
PREREQUISITES		**CATEGORY**	PC	Credit		3
Electromagnetic Theory		**Hours/Week**	L	T	P	TH
			2	1	0	3

Course Objectives:

This course provides understanding of AC machinery fundamentals, machine parts and helps to develop the skills for operating AC machines, and equips students to analyze the equivalent circuits of Induction and Synchronous Machines.

UNIT I	ALTERNATOR	6	3	0	9

Construction, types, practical rating of synchronous generators, winding factors, production of EMF, armature reaction, Synchronous reactance, phasor diagram, Methods of pre-determination of voltage regulation- Synchronous impedance, ampere turn, Potier triangle methods. Two reaction theory–Slip test, and parallel operation synchronization -Change of excitation and mechanical input

UNIT II	SYNCHRONOUS MOTOR	6	3	0	9

Theory of operation–phasor diagrams, Torque equation – Operation on infinite bus bars, variation of current and power factor with excitation. Hunting and its suppression, V and inverted V curves, Synchronous condenser, method of starting.

UNIT III	THREE PHASE INDUCTION MACHINES	6	3	0	9

Constructional details, types, production of rotating magnetic field-principle of operation and practical rating of induction motors. Need for starting – Types of starters – DOL, Rotor resistance and Auto transformer and star-delta starters. Generator action: self-excitation, operation, and applications.

UNIT IV	ANALYSIS AND TESTING OF THREE PHASE INDUCTION MOTORS	6	3	0	9

Phasor diagram, equivalent circuit, Torque equation-starting and maximum-torque, maximum-output, slip for maximum-output, Torque-slip characteristics, losses and efficiency. Testing-no load and blocked rotor tests- equivalent circuit parameters, circle diagram.

UNIT V	SINGLE PHASE INDUCTION MOTOR	6	3	0	9

Constructional details of single-phase induction motor – Double field revolving theory and operation – Equivalent circuit – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor – repulsion motor Hysteresis motor.

Total (30L+15T) = 45 Periods

Text Books:

1.	D.P. Kothari, I.J. Nagrath, “Electric Machines”, 5th Edition, McGraw-Hill Education, New York, 2017.
2.	Dr.P.S.Bimbhra, “Electrical Machinery”, Khanna Publishers, Delhi, 2nd Edition, 2021.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, “Electric Machinery”, McGraw Hill Education, 6th Edition 2017.

References:

1.	B.L.Theraja & A.K. Theraja, “Electrical Technology”, Vol.II, S.Chand& Company Ltd., New Delhi, 2015.

2	Alexander S. Langsdorf, “Theory of Alternating-Current Machinery”, Tata McGraw Hill Publications, 2001.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Familiarize with construction, working principle, synchronizing techniques and performance of Synchronous Generator.	L1: Remembering
CO2	:	Understand the working principle, torque equation, and excitation control for Synchronous Motor.	L2: Understanding
CO3	:	Operate three phase Induction machine as motor and as a generator, analyze the performance of three phase induction motor.	L4: Analyzing
CO4	:	Know double field revolving theory and starting mechanisms for single-phase induction motors.	L2: Understanding
CO5	:	Use synchronous and induction motors in practical domain with specified ratings.	L3: Applying

25PTEE202	MEASUREMENTS AND INSTRUMENTATION			SEMESTER		II
PREREQUISITES			**CATEGORY**	**PC**	**Credit**	**3**
Electric Circuit Analysis			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To educate the fundamental concepts and characteristics of measurement System
2.	To introduce the fundamentals of electrical and electronic instruments for measurement of electrical and Non-electrical quantities
3.	To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters

UNIT II	**MEASUREMENT OF POWER, ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**

Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter

UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**

Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and De Sauty's bridge

UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**

DC Potentiometer- Crompton's Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.

UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**

Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors

Total (45L+0T)= 45 Periods

Text Books:

1.	A.K. Sawhney, "A Course in Electrical & Electronics Measurement & Instrumentation", Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, "Measurements Systems- Application and Design", Tata McGraw Hill publishing company, 2015.

Reference Books:

1.	D.V.S. Moorthy, "Transducers and Instrumentation", Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, "Electronic Instrumentation", Tata McGraw Hill, 2015.
3.	Martin Reissland, "Electrical Measurements", New Age International(P) Ltd., Delhi, 2011.

E-Reference	
1.	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments.	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters.	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select and use an appropriate transducer for measurement of non-electrical quantities.	L4: Analysing

25PTEE203	ANALOG AND DIGITAL INTEGRATED CIRCUITS			SEMESTER		II
PREREQUISITES		CATEGORY	PC	Credit		3
Electron Devices and Circuits		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To impart knowledge on the characteristics and applications of Operational Amplifier, functional diagram and applications of linear ICs
2.	To simplify the switching functions
3.	To design the combinational logic circuits and sequential logic circuits

Unit I	OPERATIONAL AMPLIFIERS	9	0	0	9

Operational amplifiers - Equivalent circuit, voltage transfer curve-Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs. Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.

Unit II	APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS	9	0	0	9

DC & AC amplifiers- Summing, Scaling and Averaging amplifiers-Instrumentation amplifier - Voltage to Current converter for floating and grounded loads-Current to voltage converter-Integrator, Differentiator. Voltage comparators-Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters.

Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.

Unit III	COMBINATIONAL LOGIC CIRCUITS	9	0	0	9

Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and Quine McCluskey (Tabulation) method.

Design:Adders -Subtractors– 2 bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder.

Unit IV	SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.

Unit V	ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.

Total (45L+0T) = 45 Periods

Text Books:

1.	Ramakant A Gayakward, “Op-Amps and Linear Integrated Circuits”, Fourth Edition, Pearson Education, 2003.

2.	D.Roy Chowdhury and Shail B. Jain, "Linear Integrated Circuits", Fourth Edition, New Age International (P) Ltd Publishers, 2014.
3.	M. Morris Mano, "Digital Design" , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .
4.	S. Salivahanan and S. Arivazhagan, "Digital Circuits and Design", Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 2011
Reference Books:	
1.	Jacob Millman, Christos C.Halkias, "Integrated Electronics- Analog and Digital circuits system", Tata McGraw Hill 2003.
2.	R.P.Jain, "Modern Digital Electronics", Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, "Digital Fundamentals", Pearson Education, Inc, New Delhi, 2015
4.	Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and tabulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

25PTEE204	ELECTRICAL MACHINES LABORATORY			SEMESTER		II
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**1.5**
NIL		**Hours / Week**	**L**	**T**	**P**	**TH**
			0	**0**	**3**	**3**

Course Objectives:

1.	To expose the students to operate of DC and AC Machines and strength their experimental skill.

Experiments

1.	Open circuit and load characteristics of DC shunt generator.
2.	Load characteristics of DC long shunt and short shunt compound generator with cumulative and differential connections.
3.	Load test on DC series motor.
4.	Swinburne's test on DC machines.
5.	Speed control of DC shunt motor.
6.	Open circuit and short circuit tests on single phase transformer.
7.	Load test on single-phase transformer / three phase transformer.
8.	Predetermination of Voltage Regulation of three-phase alternator by EMF and MMF methods.
9.	V and inverted V curves of synchronous motor.
10.	Circle diagram for three phase induction motor with no load and blocked rotor test data.
11.	Load test on three-phase induction motor/single phase induction motor.
12.	Separation of losses in three phase induction motor.

Total (0 + 45P) = 45 Periods

Reference Books:

1.	G.P. Chhalotra, "Experiments in Electrical Engineering", 3rd Ed., Khanna Publishers, Delhi, 2004.
2.	C.S. Indulkar, "Laboratory Experiments in Electrical Power", 3rd Ed., Khanna Publishers, Delhi, 2010.
3.	DC machines and transformers laboratory manual prepared by the department.
4.	Synchronous and Induction Machines manual prepared by the department.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the voltage regulation of a given alternator using different methodologies and Transformer	L2: Understanding
CO2	:	Analyze the performance of a given synchronous motor under various excitation. Conditions	L4: Analyzing
CO3	:	Analyze the characteristics of a induction motor and DC machines under various load conditions	L4: Analyzing
CO4	:	Develop the equivalent circuit and analyze the characteristics of AC machine	L5: Creating
CO5	:	Do loss analysis in DC and AC machines.	L4: Analyzing

25PTEE301	CONTROL SYSTEMS		SEMESTER			III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Electrical Machines and Electric circuit Analysis		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To understand the methods of representation of Physical systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the three ways of designing compensators for a Feedback control system.

UNIT I	**MODELING OF LINEAR TIME INVARIANT SYSTEM**	**6**	**3**	**0**	**9**

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics – Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation - Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	**TIME RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Standard test signals – Time response of first order and second order systems – Time domain specifications – Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	**FREQUENCY RESPONSE ANALYSIS**	**6**	**3**	**0**	**9**

Correlation between time and frequency response: Second order systems - Frequency domain specifications – Polar plots – Bode plots – Computation of Gain Margin and Phase Margin – Constant M and N-circles – Nichols chart.

UNIT IV	**STABILITY OF CONTROL SYSTEM**	**6**	**3**	**0**	**9**

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	**COMPENSATOR AND CONTROLLER DESIGN**	**6**	**3**	**0**	**9**

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators –Design of compensators using Root Locus and Bode plot techniques- PID controller- Design using reaction curve and Ziegler- Nichols technique.

Total (30L+15T) = 45 Periods

Text Books:

1.	A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2.	I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1.	K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 5th Edition, 2021.
2.	M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2018.

E-Reference	
1.	https://nptel.ac.in/courses/107106081
2.	https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

25PTEE302	POWER ELECTRONICS		SEMESTER		III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**	**3**
Electron Devices and Circuits		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To study an overview of power semiconductor devices.
2.	To obtain the knowledge of controlled rectifiers.
3.	To acquire the principles of DC-DC converter.
4.	To understand the principles of inverters and ac voltage controllers.

UNIT I	**POWER SEMICONDUCTOR DEVICES**	**9**	**0**	**0**	**9**

Concept of power electronics- Structure, Operation, Static and Switching characteristics of power semiconductor devices: Power Diode, SCR, MOSFET, IGBT- Thyristor ratings and protection, Gate drive circuits for MOSFET and IGBT - Switching and Conduction losses in a generic power semiconductor device.

UNIT II	**PHASE CONTROLLED RECTIFIERS**	**9**	**0**	**0**	**9**

Single phase and three phase fully controlled rectifiers: Power circuit, Operation, Waveform analysis and performance parameters - Effect of source inductance for Single phase and Three phase fully controlled rectifier - Single phase and Three phase dual converters.

UNIT III	**DC TO DC CONVERTER**	**9**	**0**	**0**	**9**

Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage– control strategy –Power Circuit and steady state analysis of Buck converter, Boost converter, Buck – boost converter and SEPIC converter- Design of inductor and capacitors for DC-DC converters.

UNIT IV	**INVERTERS**	**9**	**0**	**0**	**9**

Power circuit of single phase voltage source inverter, square wave operation of the inverter, bipolar and unipolar sinusoidal modulation, modulation index and output voltage, Power circuit of a three-phase voltage source inverter, operation with three-phase sinusoidal modulation – Single phase Auto sequential Commutated Current Source Inverter.

UNIT V	**AC TO AC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction and principle of operation of Single phase and Three phase AC voltage controllers – Multistage sequence control –Applications of AC Voltage Controllers–Introduction to Matrix converters.

Total (45L+0T)= 45 Periods

Text Books:

1.	M.H.Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson Education, PHI 4th Edition, New Delhi, 2017.
2.	P .S.Bimbra, "Power Electronics" Khanna Publishers, New Delhi 2018.

Reference Books:

1.	Ned Mohan, Tore. M. Undel and, William. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley and sons, 2007.

2.	R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.
3.	M.D. Singh and K.B. Khanchandani, “Power Electronics,” McGraw Hill India, 2013.
E-Reference	
1	www.onlinecourses.nptel.ac.in/
2	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Choose suitable Power Semiconductor Device for the power conversion.	L3: Applying
CO2	:	Know the operation of converters, inverters and AC voltage controllers.	L2: Understanding
CO3	:	Analyse the performance of converters and inverters.	L4: Analyzing
CO4	:	Design converter and inverter circuits.	L3: Applying
CO5	:	Identify suitable control techniques for the converter.	L1: Remembering

25PTEE303	MICROPROCESSORS AND MICROCONTROLLERS		SEMESTER			III
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To study the architecture of μP8085 and μC 8051
2.	To study the Interrupt structure of 8085 and 8051.
3.	To do simple applications development with programming 8085 and 8051.

UNIT I	**8085 8 BIT MICROPROCESSOR**	**9**	**0**	**0**	**9**
Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.					
UNIT II	**8051 8 BIT MICROCONTROLLER**	**9**	**0**	**0**	**9**
Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.					
UNIT III	**INTERFACING WITH 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**
Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.					
UNIT IV	**EXTERNAL COMMUNICATION INTERFACE**	**9**	**0**	**0**	**9**
Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.					
UNIT V	**APPLICATIONS OF MICROCONTROLLERS**	**9**	**0**	**0**	**9**
Simple programming exercises- key board and display interface –Control of servo motor stepper motor control-Application to automation systems.					

Total (45L+0T)= 45 Periods

Text Books:

1.	R.S. Gaonkar, 'Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2004.
3.	Muhammad Ali Mazidi& Janice GilliMazidi, R.D.Kinely 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003.

Reference Books:

1.	R. Kamal, "Embedded System", McGraw Hill Education,2009.
2.	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

E-Reference

1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of Microprocessor and Microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

25PTCS301	C PROGRAMMING FOR ELECTRICAL ENGINEERS		SEMESTER			III
PREREQUISITES		**CATEGORY**	**ES**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide complete knowledge about the programming concepts of C language.
2.	To provide knowledge to develop solution for algebraic equations.

UNIT I	**C Programming Basics and Control Statements**	**9**	**0**	**0**	**9**
C Character set- Identifies and Keywords- Data Type- Declarations-Expressions-Statements and Symbolic constants-Operators – Arithmetic Operators – Unary operators – Relational and Logical Operators – Assignment operators – Conditional operators- Managing Input and Output operations- Decision Making-Branching and Looping statements.					
UNIT II	**Arrays and Strings**	**9**	**0**	**0**	**9**
Pre-processor directives-Storage classes-Arrays – Initialization – Declaration – one dimensional and two dimensional arrays. Strings - String operations – String handling functions-Simple programs-sorting-searching.					
UNIT III	**Functions and Pointers**	**9**	**0**	**0**	**9**
Function – Library functions and user-defined functions – Function prototypes and function definitions – Call by value – Call by reference – Recursion – Pointers - Definition – Initialization – Pointers arithmetic – Pointers and arrays.					
UNIT IV	**Structures, Unions and File**	**9**	**0**	**0**	**9**
Introduction – need for structure data type – structure definition – Structure declaration – Structure within a structure – Passing structures to functions – Array of structures – Pointers to structures-Union-basic file operation.					
UNIT V	**Solving system of algebraic equations**	**9**	**0**	**0**	**9**
Solving system of simple differential equations, Numerical integration, Numerical differentiation, simultaneous equations / Non simultaneous equations. Plotting of functions					
					Total (45L+0T)= 45 Periods

Text Books:

1.	E.Balagurusamy, “Programming in ANSI C” fourth Edition, Tata McGraw-Hill, 2008.(Unit II-V).

Reference Books:

1.	Byron S Gottfried, “Programming with C”, Schaum’s Outlines, Second Edition, Tata McGraw-Hill,2006.
2.	Yashavant P. Kanetkar. “Let Us C”, BPB Publications, 2011.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Familiarize C programming concepts.	L2: Understanding
CO2	:	Apply the concept of C programming to develop solution.	L3: Applying
CO3	:	Develop the C programming concepts for solving algebraic equations.	L3: Applying

25PTEE304	MICROPROCESSOR AND MICROCONTROLLER LABORATORY				SEMESTER		III
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**1**
Analog and Digital Integrated Circuits, Microprocessor and Microcontroller			**Hours / Week**	**L**	**T**	**P**	**TH**
				0	**0**	**2**	**2**

Course Objectives:

1.	Able to write own programs for different applications and interface the programs for interconnected digital systems

LIST OF EXPERIMENTS:

1. Simple arithmetic operations: addition / subtraction / multiplication / division.
2. Programming with control instructions:
    a. Ascending / Descending order, Maximum / Minimum of numbers
    b. Programs using Rotate instructions
    c. Hex / ASCII / BCD code conversions.
3. Interface Experiments: with 8085
   A/D Interfacing. & D/A Interfacing.
4. Traffic light controller.
5. I/O Port / Serial communication
6. Programming Practices with Simulators/Emulators/open source
7. Keyboard interfacing
8. LCD interfacing 4bit/8bit mode
9. Demonstration of basic instructions with 8051 Micro controller execution, including:
    a. Conditional jumps, looping
    b. Calling subroutines.
10. Programming I/O Port 8051
    a. Interface with external A/D & D/A
    b. Interface with stepper motor
11. Interrupt programming with external sensors/ devices
12. Programming for communication using Zigbee protocol.

Total (0T + 30P) = 30 Periods

Reference Books:

1. R. S. Gaonkar, "Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996.
2. K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3. M.A.Mazidi, J.G. Mazidi and R. D. McKinlay, "The 8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007.
4. R. Kamal, "Embedded System", McGraw Hill Education, 2009.
5. D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Write coding to implement different types of algorithms	L1: Remembering
CO2	:	Design and implement simple controllers	L3: Applying
CO3	:	Use simulators and emulators for debugging and verifying codes	L3: Applying
CO4	:	Write efficient codes using interrupts for time critical applications	L4: Analyzing
CO5	:	Interface any application module to microprocessor/microcontroller.	L5: Evaluating

25PTEE401	POWER GENERATION, TRANSMISSION AND DISTRIBUTION SYSTEM				SEMESTER		IV
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Electric circuit analysis, Electromagnetic Theory			**Hours/Week**	**L**	**T**	**P**	**TH**
				2	**1**	**0**	**3**

Course Objectives:

1.	To impart knowledge on power generation plants and Substation
2.	To study the line parameters and analyze the performance of the transmission system
3.	To learn insulators, cables and grounding methodologies for power system

UNIT I	**POWER GENERATION SYSTEMS**	**6**	**3**	**0**	**9**

Structure of electric power system-Terms, factors and significance of Load curve –Economics of Power Generation-Cost of Electrical Energy- Power generating Station: layout and operation of Thermal power plant, Hydroelectric power plant and Nuclear power plants –Comparison of power plants.

UNIT II	**TRANSMISSION LINE PARAMETERS**	**6**	**3**	**0**	**9**

Line resistance- Inductance and capacitance calculations of single phase and three phase transmission lines with single and double circuits–Effect of earth on the capacitance of the transmission line– Skin and proximity effects-Inductive interference between power and communication lines.

UNIT III	**PERFORMANCE OF TRANSMISSION LINES**	**6**	**3**	**0**	**9**

Representation of Lines-Performance of Short line, medium line and long transmission line; equivalent circuits, Phasor Diagrams, transmission efficiency and voltage regulation, ABCD constants-surge-impedance loading-Ferranti effect and corona effect.

UNIT IV	**OVERHEAD LINE INSULATORS AND CABLES**	**6**	**3**	**0**	**9**

Insulators: Types, Potential distribution over a string of suspension insulators- improvement of string efficiency. Underground cables: Constructional features of LT and HT cables, capacitance of single core and 3- core cables, dielectric stress in a single core cable- grading of cables, thermal resistance of dielectric of a single core cable.

UNIT V	**SUBSTATION, GROUNDING SYSTEM AND DISTRIBUTION SYSTEM**	**6**	**3**	**0**	**9**

Substation: Lay out and operation-bus-bar arrangements in sub stations- Grounding: Need and Types, Neutral grounding and Resonant grounding- Transformer Earthling- Distribution system: Classification, Layout of AC and DC distribution, Connection Schemes of Distribution system.

Total (30L+15T)= 45 Periods

Text Books:

1.	C.L. Wadhwa, "Electrical Power Systems", New age International (P) Ltd., 2018.
2.	S.N.Singh, "Electric Power Generation, Transmission and Distribution", Second Edition, PHI Pvt. Ltd., New Delhi, 2012.

Reference Books:

1.	Ray, "Electrical Power systems: Concepts, Theory and Practice", PHI Pvt.Ltd., New Delhi,2012.
2.	V.K. Mehta, Rohit Mehta, "Principles of Power System", S.Chand & Company Ltd., New Delhi, 2012

E-Reference	
1.	https://archive.nptel.ac.in/courses/108/102/108102047/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the operation of generating stations and substations	L2: Understanding
CO2	:	Model the transmission lines using system parameters	L3: Applying
CO3	:	Analyze the performance of different types of transmission lines	L4: Analysing
CO4	:	Select an appropriate insulator and cable for transmission and distribution system	L3: Applying
CO5	:	Describe the substation components and grounding techniques.	L1: Remembering

25PTEE402	ELECTRICAL DRIVES AND CONTROL		SEMESTER			IV
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know about the Analyze the operation of the chopper fed dc drive, both qualitatively and quantitatively.
2.	To understand the Operation and performance of AC motor drives.

UNIT I	DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES	9	0	0	9

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE	9	0	0	9

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	INDUCTION MOTOR CHARACTERISTICS	9	0	0	9

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	CONTROL OF SLIP RING INDUCTION MOTOR	9	0	0	9

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

UNIT V	CONTROL OF SRM AND BLDC MOTOR DRIVES.	9	0	0	9

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

Total (45L+0T)= 45 Periods

Text Books:

1.	G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, 1989.
2.	R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall,2010
3.	Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, "Fundamentals of Electrical Drives", CRC Press, 2012.
2.	W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.

E-Reference	
1.	https://www.iith.ac.in/~ketan/drives.htmL

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying
CO5	:	Analyze the SRM and BLDC motor drive control.	L4: Analyzing

25PTEE403	INDUSTRIAL MANAGEMENT AND ECONOMICS		SEMESTER			IV
PREREQUISITES		CATEGORY	PC	Credit		3
Mathematics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1. To understand the concept of management, economics and Indian financial system

UNIT I	MODERN CONCEPT OF MANAGEMENT	9	0	0	9

Scientific management-Functions of management-Planning-Organising- Staffing-Directing- Motivating- Communicating- Co-ordinating- Controlling-Organizational structures- Line, Line and staff and Functional relationships- Span of control-Delegation- Management by Objectives.

UNIT II	PERSONNEL MANAGEMENT	9	0	0	9

Objectives and functions of personnel management- Recruitment-Selection and training of workers- Labour Welfare- Industrial Fatigue- Industrial disputes-Trade Unions- Quality circles. Formation of companies: Proprietory-Partnership-Joint stock companies- Public sector- Joint sector and Co-operative sector.

UNIT III	MARKETING MANAGEMENT	9	0	0	9

Pricing- Promotion- Channels of distribution- Market research-Advertising. Production Management: Batch and mass production- Inventory control- EOQ-Project planning by PERT/CPM- Construction of Network (Basic ideas only).

UNIT IV	BASICS OF ECONOMICS	9	0	0	9

Theory of demand and supply- Price mechanism- Factors of production- Land, labour, capital and organization- National income- Difficulties in estimation- Taxation- Direct and indirect taxes- Progressive and regressive- Black money- Inflation-Causes and consequences.

UNIT V	INDIAN FINANCIAL SYSTEM	9	0	0	9

Reserve bank of India: Functions- Commercial banking system-Development financial institutions- IDBI- ICICI- SIDBI- IRBI-NABARD- Investment institutions-UTI- Insurance companies- Indian capital market- Stock market- Functions- Role of the public sector- Privatisation- Multinational corporations and their impact on the Indian economy

Total (45L+0T)= 45 Periods

Text Books:

1. O P Khanna , "Industrial Management" , Dhanpat Rai Publications,4th edition, 1980.
2. Philip Kotler, Kevin Lane Keller, SweeHoon Ang, Chin Tiong Tan, Siew Meng Leong, "Marketing Management: An Asian Perspective" Pearson Education Limited, 7th Edition, 2017
3. A. N. Agrawal, "Indian Economy",Vikas Publishing House PVT, 4th edition, 1978.

Reference Books:

1. K. K. Ahuja, "Industrial management" Khanna Publishers, 1978.
2. K.K Dewett, ShyamLal , "Modern economic theory" S Chand and Company Limited, 2008

E-References:

1 www.onlinecourses.nptel.ac.in/

2	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the concepts of management	L2: Understanding
CO2	:	Remember various types of management.	L1: Remembering
CO3	:	Analyze the Indian economics	L4: Analyzing
CO4	:	Create an organization efficiently for its upliftment	L6: Creating
CO5	:	Apply marketing concept to any organization to earn more profit.	L3: Applying

25PTCY101	ENVIRONMENTAL SCIENCE AND ENGINEERING		SEMESTER		IV	
PREREQUISITES		CATEGORY	L	T	P	C
Nil		BS	3	0	0	3

Course Objectives: To make the students conversant with the

1.	Basic concepts of ecosystem and biodiversity.
2.	Causes, effects and control measures of pollution.
3.	Facilitate the understanding of natural resources.
4.	Familiarize the concept of sustainable development and water conservation.
5.	Inculcate students with comprehensive knowledge of green technologies.

UNIT I	ECOSYSTEM AND BIODIVERSITY	9	0	0	9

Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.
Biodiversity – types and values of biodiversity, hot spots of biodiversity, threat to biodiversity, endangered and endemic species, conservation of biodiversity – In-situ and Ex-situ conservation.

UNIT II	ENVIRONMENTAL POLLUTION	9	0	0	9

Definition - causes, effects and control measures of: Air pollution, Water pollution and Noise pollution. Solid waste
management: causes, effects and control measures of municipal solid wastes - role of an individual in prevention of pollution - pollution case studies. E-waste management.

UNIT III	NATURAL RESOURCES	9	0	0	9

Forest resources**:** Use and over – exploitation, deforestation, timber extraction, mining, dams and other effects on forest and tribal people. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources.
Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources.

UNIT IV	SOCIAL ISSUES AND THE ENVIRONMENT	9	0	0	9

From unsustainable to sustainable development, objectives and significance of sustainable development - urban problems related to energy - water conservation, rain water harvesting, watershed management - resettlement and rehabilitation of people; its problems and concerns, - environmental ethics: Issues and possible solutions - Acid rain, greenhouse effect, global warming and ozone layer depletion.

UNIT V	GREEN ENVIRONMENTAL PRACTICES	9	0	0	9

Zero waste and R concept, Environmental Impact Assessment (EIA). Green buildings, Green materials, Sustainable transport and Sustainable energy. Concept of carbon credit and carbon Footprint and sequestration. Role of information technology i
environment and human health.

Total (45L+0T) = 45 Periods

Text Books:

1.	Anubha Kaushik and C. P. Kaushik‟s "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers, 2018.
2.	Benny Joseph, „Environmental Science and Engineering‟, Tata McGraw-Hill, New Delhi,2016.
3.	Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengag learning.
4.	Environment Impact Assessment Guidelines, Notification of Government of India, 2006.

Reference Books:

1.	Rajagopalan, R, „Environmental Studies-From Crisis to Cure‟, Oxford University Press, Third Edition, 2015.
2.	Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013.

E-Reference	
1	www.onlinecourses.nptel.ac.in/
2	www.ePathshala.nic.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To Summarize the importance of ecosystem and biodiversity.	L2: Understanding
CO2	:	To interpret the impact of pollution in a global environments and societal well-being.	L2: Understanding
CO3	:	To apply their understanding of natural resources to develop practical solutions for environmental issues.	L3: Applying
CO4	:	To organize the concepts of sustainable development and recognize the significance of conserving water.	L3: Applying
CO5	:	To analyze the application of green technology concepts in creating and implementing sustainable solutions.	L4: Analyzing

25PTEE404	POWER ELECTRONICS AND ENERGY SYSTEMS LABORATORY				SEMESTER		V
PREREQUISITES		**CATEGORY**		**PC**	**Credit**		**1.5**
Power Electronics		**Hours/Week**		**L**	**T**	**P**	**TH**
				0	**0**	**3**	**3**

Course Objectives:

1.	To simulate and analyze the performance of different power electronic converter circuits
2.	To conduct an experiments for power devices and basic power converter circuits

LIST OF EXPERIMENTS:

1	V-I Characteristics of power diode and SCR
2	Characteristics of Power MOSFET and IGBT
3	Single phase AC to DC fully controlled converter
4	Single phase PWM rectifiers
5	Buck and Boost Converters
6	MOSFET based single-phase PWM inverter
7	IGBT based three-phase PWM inverter
8	Single phase AC voltage controller
9	Simulation for Single phase and three phase dual converters
10	Simulation of Matrix Converter and SEPIC converter
11	Simulation study on Solar PV Energy System
12	Simulation of Grid connected Solar PV Energy System
13	Simulation study on Wind Energy Conversion System
14	Simulation on Performance Assessment of Fuel Cell energy conversion system.

Total (0L+45P)= 45 Periods

Text Books:

1.	M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2009.
2.	P.S.Bimbra "Power Electronics" Khanna Publishers, New Delhi 2016.

Reference Books:

1.	Ned Mohan, Tore. M. Undel and, William. P. Robbins, 'Power Electronics: Converters, Applications and Design', John Wiley and sons, 2007.
2.	M.D. Singh and K.B. Khanchandani, "Power Electronics," McGraw Hill India, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Level**
CO1	:	Analyze the characteristics of MOSFET, SCR and IGBT.	L4: Analyzing
CO2	:	Examine the performance of DC-DC Converters and inverters.	L3: Applying
CO3	:	Design and control of inverters with different modulations.	L3: Applying
CO4	:	Analyze the performance of power converters with simulation studies	L4: Analyzing
CO5	:	Demonstrate the operation of Solar and wind energy conversation system	L3: Applying

25PTEE501	POWER SYSTEM ANALYSIS AND STABILITY		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Circuit Theory, Electrical Machines, Power Generation, Transmission and Distribution System		**Hours/Week**	**L**	**T**	**P**	**TH**
			2	**1**	**0**	**3**

Course Objectives:

1.	To model the power system under steady state operating condition
2.	To apply efficient numerical methods to solve the power flow problem
3.	To model and analyse the power systems under abnormal (or) fault conditions
4.	To model and analyse the transient behaviour of power system when it is subjected to a fault.

UNIT I	POWER SYSTEM OVERVIEW AND MODELLING	6	3	0	9

Basic components of modern power system - Per-phase analysis: Generator model - Synchronous motor model- Three-phase transformer model - Three-winding transformer model - Line model, Load model- Per unit quantities :- Changing the base of per-unit quantities - Single line diagram -Impedance and reactance diagrams.

UNIT II	POWER FLOW ANALYSIS	6	3	0	9

Bus classification – Bus admittance matrix Formulation: Direct inspection method and Singular transformation method - Development of power flow model - solution of load flow equations: Gauss Seidel method - Newton Raphson method- Fast decoupled method – Flowcharts – Comparison of the three power flow solution methods.

UNIT III	FAULT ANALYSIS - BALANCED FAULT	6	3	0	9

Importance of short circuit studies-Assumptions in short circuit analysis – Balanced three phase fault – Short circuit capacity - Algorithm for formation of the bus impedance matrix- Systematic fault analysis using bus impedance matrix - Post fault bus voltages – Fault level - Current limiting reactors - Selection of circuit breakers.

UNIT IV	FAULT ANALYSIS - UNBALANCED FAULT	6	3	0	9

Fundamentals of symmetrical components – Sequence impedances – Construction of sequence networks – Unsymmetrical faults on power system: Single line-ground fault, line-line fault – Double line-ground fault- Unbalanced fault analysis using Thevenin's theorem and Z-bus computation of post fault currents in symmetrical component and phasor domains .

UNIT V	STABILITY STUDIES	6	3	0	9

Importance of stability studies – Classification of power system stability – Stability limits – Power angle equation- Inertia constant- Swing equation of single-machine connected to infinite bus – Solution of swing equation by step-by-step method-II – Modified Euler's method – Runge-Kutta method – Equal area criterion – Critical clearing angle and time -Factors affecting transient stability – Techniques for transient stability improvement.

Total (30L+15T)= 45 Periods

Text Books:

1.	Hadi Saadat, "Power System Analysis", Tata McGraw Hill Publishers, New Delhi, 3rd edition, 2011.
2.	D.P.Kothari, and I.J.Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education Private limited, New Delhi, Fourth Edition, 2019.

Reference Books:

1.	John J. Grainger and W.D. Stevenson Jr., "Power System Analysis", McGraw Hill Inc., New Delhi, 2017.

2.	B.R. Gupta, "Power System Analysis and Design", S.Chand& Co. Ltd., New Delhi, 2012 .
3.	C. L. Wadhwa, "Electrical Power Systems", New Age International Publishers, New Delhi, 2021.
E-Reference	
1	https://onlinecourses.nptel.ac.in/, for power system analysis course, IIT Kharagpur
2	NPTEL courses on Power System Generation, Transmission and Distribution, IIT Delhi.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Develop the single line diagram for the power system.	L3: Applying
CO2	:	Perform and analyse load flow computations using bus admittance matrix	L4: Analysing
CO3	:	Perform and analyse balanced fault using bus impedance matrix	L4: Analysing
CO4	:	Develop computational models for unsymmetrical fault analysis in power systems	L6: Creating
CO5	:	Demonstrate the transient stability studies.	L3: Applying

25PTEE502	POWER SYSTEM PROTECTION AND SWITCHGEAR		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Power Generation, Transmission and Distribution systems, Measurements and Instrumentation.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To acquire knowledge about the power system protection and switchgear components.
2.	To understand the concepts of various protection schemes for power system equipment.
3.	To study the functioning of static relays and numerical protection schemes.

UNIT I	**PROTECTION AND RELAYS**	**9**	**0**	**0**	**9**

Need for protective system – Protection system components – Zones of protection – Primary and Backup protection - Essential qualities of protection – Basic principle of operation of relays – classifications of relays - Universal torque equation – Basic Relay terminology : relay time, pick up and reset current, PSM and TSM – calculation of relay operating time- construction and principle of operation: Electromagnetic relays – directional and non-directional over current relays – Distance relays: Impedance, reactance and mho type – Differential relays – Translay relay – Negative sequential relays and under frequency relays.

UNIT II	**CIRCUIT BREAKERS**	**9**	**0**	**0**	**9**

HRC fuses : construction, working, characteristics, and applications - Physics of arcing phenomenon and arc interruption theories –recovery voltage and restriking voltage – expression for RRRV – current chopping – interruption of capacitive current – Resistance switching - Types of circuit breakers - Minimum oil, Air-blast , air break, SF_6, MCBs, MCCBs and Vacuum circuit breakers - Problems of circuit interruption: - Rating of circuit breakers – Testing of circuit breakers – Selection of circuit breakers - HVDC circuit breakers.

UNIT III	**ALTERNATOR AND TRANSFORMER PROTECTION**	**9**	**0**	**0**	**9**

Alternator protection: Stator protection : Differential protection- Percentage differential relays, balanced earth-fault protection, Stator inter turn protection - Field ground fault protection - Protection of stator windings by overvoltage relays - Protection against stator open circuits, loss of synchronism, loss of excitation, rotor fault protection - numerical problems on % winding unprotected.

Transformer protection: differential protection – biased differential protection-numerical problem on design of CTs ratio - restricted earth fault relay -Buchholz relay protection- harmonic restraint relay.

UNIT IV	**MOTOR, BUS BAR AND TRANSMISSION LINE PROTECTION**	**9**	**0**	**0**	**9**

AC Motor protection against short circuit, overload, and single phasing.
Bus bar protection: Differential and Fault bus protection – Transmission line protection: Over Current, Carrier Current, distance or impedance relay, Translay Relay.

UNIT V	**STATIC RELAYS AND NUMERICAL PROTECTION**	**9**	**0**	**0**	**9**

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distance protection of transmission line.

Total (45L+0T)= 45 Periods

Text Books:

1. Sunil S.Rao, 'Switchgear and Protection', Khanna Publishers, New Delhi, Fourth Edition, 2010.

2	Badri Ram and Vishwakarma D N, “Power System Protection and Switchgear”, Tata McGraw Hill, 2015
3	Chakrabarti A, Soni, M L, Gupta P V, and Bhatnagar, “ A Text Book on Power System Engineering”, Dhanpat Rai & Co. (Pvt.) Ltd., Delhi, Second Revised Edition 2017.
4	Ravindranath. B and Chander, N, “Power System Protection and Switchgear”, New Age International (P) Ltd, Second Edition, 2018.
Reference Books:	
1	Arun Ingole, “Switchgear and Protection”, Pearson Education India, 2017.
2	Madhav Rao, T. S., “Power System Protection Static Relays with Microprocessor Applications”, Tata McGraw-Hill, 1998.
3	Paithankar, Y. G and Bhide, S. R, “Fundamentals of Power System Protection”, Prentice Hall of India Private Ltd, New Delhi, 2010.
4	C.L.Wadhwa, “Electrical Power Systems”, 6th Edition, New Age International (P) Ltd., 2010.
E-References:	
1.	NPTEL Course: Power System Protection - Prof. S.A. Soman, IIT-B.
2.	NPTEL Course: Power System Protection – organized by IIT-B.
3.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Analyse the characteristics and functions of protective relays.	L3: Applying
CO2	:	Acquire knowledge on functioning of circuit breaker.	L2: Understanding
CO3	:	Assess the protection schemes of alternator and transformer.	L1: Remembering
CO4	:	Assess the protection schemes of motor, bus bar and transmission lines.	L1: Remembering
CO5	:	Develop the knowledge on static and numeric type relays.	L4: Analysing

25PTHS501	UNIVERSAL HUMAN VALUES			SEMESTER			V
PREREQUISITE:		CATEGORY		HS	Credit		3
Universal human values introduction		Hours/Week		L	T	P	TH
				2	1	0	3

COURSE OBJECTIVES

1.	To development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2.	To understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3.	To strengthening of self-reflection.
4.	To development of commitment and courage to act.

UNIT I	BASIC CONCEPTS OF HUMAN VALUES	6	3	0	9

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education. Purpose and motivation for the course, recapitulation from Universal Human Values-I. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario Method to fulfil the above human aspirations- understanding and living in harmony at various levels.

UNIT II	UNDERSTANDING HARMONY IN THE HUMAN BEING	6	3	0	9

Understanding Harmony in the Human Being - Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail Programs to ensure Sanyam and Health.

UNIT III	UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY	6	3	0	9

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

UNIT IV	UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE	6	3	0	9

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence. Understanding the harmony in the Nature. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature. Understanding Existence as Co-existence of mutually interacting units in all- pervasive space. Holistic perception of harmony at all levels of existence.

UNIT V	HOLISTIC UNDERSTANDING OF HARMONY	6	3	0	9

Implications of the above Holistic Understanding of Harmony on Professional Ethics. Natural acceptance of human values. Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in professional ethics, Strategy for transition from the present state to Universal Human Order.
Total (30L + 15T) = 45 Periods

REFERENCE BOOKS:	
1.	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010
REFERENCE BOOKS:	
1.	Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2.	Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3.	The Story of Stuff (Book)
4.	The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5.	Small is Beautiful - E. F Schumacher.
6.	Slow is Beautiful - Cecile Andrews
7.	Economy of Permanence - J C Kumarappa
8.	Bharat Mein Angreji Raj - PanditSunderlal
9.	Rediscovering India - by Dharampal
10.	Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11.	India Wins Freedom - Maulana Abdul Kalam Azad
12.	Vivekananda - Romain Rolland (English)
13.	Gandhi - Romain Rolland (English)

COURSE OUTCOMES: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Become more aware of themselves, and their surroundings (family, society, nature) and become more responsible in life	L5: Evaluating
CO2	:	Handle problems with sustainable solutions, while keeping human relationships and human nature in mind	L3: Applying
CO3	:	Become sensitive to their commitment towards what they have understood (human values, human relationship and human society)	L5: Evaluating
CO4	:	Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.	L3: Applying

25PTEE601	SOLAR AND WIND ENERGY CONVERSION SYSTEMS		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Engineering Physics, Electrical Machines and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concepts of power generation through Solar and Wind Power
2.	To learn the optimal extraction of renewable power and their integration to grid

UNIT I	FUNDAMENTALS OF SOLAR ENERGY	9	0	0	9

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

UNIT II	FUNDAMENTALS OF WIND ENERGY	9	0	0	9

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

UNIT III	SOLAR PHOTOVOLTAICS	9	0	0	9

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT- P&O, Incremental conductance) algorithms - Converter Control.

UNIT IV	WIND GENERATOR TOPOLOGIES	9	0	0	9

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power converters. Generator-Converter configurations, Converter Control.

UNIT V	GRID INTEGRATION	9	0	0	9

Overview of grid code technical requirements. Fault ride-through for wind farms – real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

Total (45L+0T) = 45 Periods

Text Books:

1.	Chetan Singh Solanki, Solar Photovoltaics, "Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2009.
2.	T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2012, 2nd edition.
3	Bimbhra, P.S, "Power Electronics", Khanna Publishers, New Delhi, 4th Edition, 2018.
4.	Rashid M.H., "Power Electronics: Circuits, Devices and Applications", Pearson, 3rd Edition, 2013.

Reference Books:

1.	Rai. G.D., "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2011.
2.	G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2013.
3.	G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.

4.	H. Siegfried and R. Waddington, “Grid integration of wind energy conversion systems” John Wiley India Sons Ltd.,2006.
5.	Mohan. N. et al. “Power Electronics: Converters, Application and Design”, Wiley India (P) Ltd, New Delhi, 2008.
E – References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the physics behind the solar and wind power generation	L2: Understanding
CO2	:	Implement the optimal extraction techniques in renewable power generation	L3: Applying
CO3	:	Apply power electronics to renewable power optimization	L3: Applying
CO4	:	Understand integration techniques used, power quality issues and their mitigation	L2: Understanding
CO5	:	Device methods to create an approximate energy conversion systems.	L6: Creating

25PTEE602	**SMART GRID TECHNOLOGIES**			**SEMESTER**			**VI**
PREREQUISITES			**CATEGORY**	**PC**	**Credit**		**3**
Power Generation, Transmission and Distribution System			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To learn communication and automation technologies and high-performance computing for smart operation of power grid.

UNIT I	**SMART GRID ARCHITECTURE**	**9**	**0**	**0**	**9**

Introduction-Conceptual model of Smart Grid, Smart Grid architecture and Components, Smart Grid Control, Smart Grid Characteristics, Smart Grid Enabling Technologies, Stages for Grid Modernization, Smart Grid Benefits and Challenges

UNIT II	**COMMUNICATION AND INFORMATION SECURITY**	**9**	**0**	**0**	**9**

Requirements of Smart Grid Communications, Communication infrastructure for the Smart Grid, communication technologies for Smart Grid, Information Layer of Smart Grid, SG Security Objectives, Cyber Security Requirements for Smart Grid,

UNIT III	**CONTROL AND AUTOMATION TECHNOLOGIES**	**9**	**0**	**0**	**9**

Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Demand-side integration (DSI): Definitions and services provided by DSI, Substation automation equipment: architecture, components and functions, Intelligent electronic devices (IED), Relay IED, Bay controller.

UNIT IV	**SMART TRANSMISSION AND DISTRIBUTION MANAGEMENT SYSTEMS**	**9**	**0**	**0**	**9**

Structure of Energy management systems- Phasor Measurement Unit(PMU) - Wide-Area Measurement (WAM) for transmission Systems- Structure and main components of Distribution Management System- Supervisory Control and Data Acquisition (SCADA)- Customer information system

UNIT V	**CLOUD COMPUTING AND DATA MANAGEMENT IN SMART GRID**	**9**	**0**	**0**	**9**

Relationship between Smart Grid, cloud computing, and big data, Cloud Computing Characteristics in Improving Smart Grid, Cloud Computing Service Models, Cloud computing platform coupled with Smart Grid, Cloud Applications for Energy Management, Privacy Information Impacts on Smart Grid, Meter Data Management for Smart Grid

Total (45L+0T)= 45 Periods

Text Books:

1.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "SmartGrid: Technology and Applications", Wiley, 2012
2.	Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase, CRC, 2018.

Reference Books:

1.	James Momoh "Smart Grid Fundamentals of Design and Analysis", Wiley, 2012.

E-Reference:

1.	https://archive.nptel.ac.in/courses/108/107/108107113/

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Describe the Smart Grid modernization process and its present developments.	L1: Remembering
CO2	:	Select the suitable communication networks for smart grid applications	L4: Analyzing
CO3	:	Use a suitable smart device for Smart Grid operation	L3: Applying
CO4	:	Illustrate a smart transmission and distribution system using PMU, WAM and SCADA	L4: Analyzing
CO5	:	Explain the need of high end computing and big data analytics in smart grid	L2: Understanding

25PTEE603	SPECIAL ELECTRICAL MACHINES			SEMESTER			VI
PREREQUISITES			CATEGORY	PE	Credit		3
Electrical Machines, Power Electronics.			Hours/Week	L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To learn the fundamental concepts of special electrical machines.
2.	To select proper special machines based on applications.

UNIT I	**SYNCHRONOUS RELUCTANCE MOTORS**	**9**	**0**	**0**	**9**

Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor.

UNIT II	**PERMANENT MAGNET BRUSHLESS D.C. MOTORS**	**9**	**0**	**0**	**9**

Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control.

UNIT III	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**9**	**0**	**0**	**9**

Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

UNIT IV	**SWITCHED RELUCTANCE MOTORS**	**9**	**0**	**0**	**9**

Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control.

UNIT V	**STEPPING MOTORS**	**9**	**0**	**0**	**9**

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits

Total (45L+0T)= 45 Periods

Text Books:

1.	T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives‟, Clarendon Press, Oxford, 1989.
2.	P.P. Acarnley, "Stepping Motors – A Guide to Motor Theory and Practice‟, Peter Perengrinus, London, 1982.

Reference Books:

1.	R. Krishnan, "Switched reluctance motor drives", CRC Press, 2001.
2.	R. Krishnan , "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, 2010

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the principles behind the different special machines.	L2: Understanding
CO2	:	Apply the electromagnetic concepts for development of EMF and Torque in machines.	L3: Applying
CO3	:	Select the control structure in terms of hardware to control the special machines.	L4: Analyzing
CO4	:	Analyze appropriate control techniques for efficient control of special machines.	L4: Analyzing
CO5	:	Develop strategy and methods to implement suitable application-based projects.	L2: Understanding

<table>
<tr><td colspan="2">25PTEE701</td><td colspan="2">HIGH VOLTAGE ENGINEERING</td><td colspan="3">SEMESTER</td><td>VII</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>CATEGORY</td><td>PC</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Measurements and Instrumentation, Power Generation, Transmission and Distribution system</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To expose the various types of over voltage transients and their effect on power system.</td></tr>
<tr><td>2.</td><td colspan="7">To introduce the concept of insulation co-ordination technique.</td></tr>
<tr><td>3.</td><td colspan="7">To provide an overview of solid, liquid and gaseous dielectrics breakdown mechanism</td></tr>
<tr><td>4.</td><td colspan="7">To show how to generate over voltages in the HV testing laboratory</td></tr>
<tr><td>5.</td><td colspan="7">To show how to measure of high voltage and current quantity in HV testing laboratory</td></tr>
<tr><td>6.</td><td colspan="7">To introduce testing procedure of HV power apparatus.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS AND INSULATION CO-ORDINATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Causes of over voltages and its effect on power system – Lightning, switching surges and temporary over voltages – Reflection and Refraction of travelling waves – Bewley lattice diagram-protection against over voltages; Principle of Insulation Coordination on High voltage and Extra high voltage power systems.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">DIELECTRIC BREAKDOWN</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Properties of Dielectric materials- Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown - Conduction and Breakdown in pure and commercial liquids dielectrics – Breakdown mechanisms in solid and composite dielectrics- Application of insulating materials in electrical equipment.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Generation of High DC voltages: Rectifiers, voltage multipliers and Van de Graff generator- Generation of High AC voltages: cascaded transformer, resonant transformer and tesla coil- Generation of High impulse voltages: single and multistage Marx circuits - Generation of switching voltages - Generation of impulse currents. Tripping and control of impulse generators.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Measurement of high DC, AC, impulse voltages – Measurement of high currents: Direct, Alternating and Impulse – digital techniques in impulse voltage and current measurements.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">HIGH VOLTAGE TESTING OF ELECTRICAL POWER APPARATUS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Overviews of International and Indian standards- laboratory test procedure: multi-level method, Up and Down method - HV Testing of Insulators, Bushings, Circuit Breakers, Power transformers, Surge Arresters, Power capacitors and Cables.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8" align="right">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="8">Text Books:</td></tr>
<tr><td>1.</td><td colspan="7">M.S. Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill Publishing Company Ltd, New Delhi, Fifth Edition, 2013.</td></tr>
<tr><td colspan="8">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="7">E. Kuffel W.S. Zaengl, and J.Kuffel , 'High Voltage Engineering Fundamentals', Newnes Publishers, Second Edition,</td></tr>
</table>

	Elsevier, New Delhi, 2005.
2.	C.L. Wadhwa, 'High Voltage Engineering', New Age International (P) Ltd Publishers, Fourth Edition, 2020.
3.	Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International (P) Ltd Publishers, Third Edition, 2006.
E-references	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	NPTEL courses on High Voltage Engineering, IIT Kanpur.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the various over voltages and its effect on power system.	L2: Understanding
CO2	:	Understand high voltage breakdown phenomena in insulating materials.	L2: Understanding
CO3	:	Explain the method of generating high DC, AC and impulse voltages	L3: Applying
CO4	:	Use appropriate procedure for measurement of high DC, AC and impulse currents.	L3: Applying
CO5	:	Comprehend the HV test procedures on electrical apparatus as per the Indian standards.	L2: Understanding

25PTEE702	PROJECT WORK			SEMESTER			VII
PREREQUISITE:		**CATEGORY**		**EEC**	**Credit**		**3**
		Hours/Week		**L**	**T**	**P**	**TH**
				0	**0**	**6**	**6**

COURSE OBJECTIVES:

The student should be made to learn methodology to select a good project and able to work in a team leading to development of hardware/software product. Prepare a good technical report. Gain Motivation to present the ideas behind the project with clarity.

GUIDELINES AND EVALUATION

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of any power component / circuit / sensor / Activator / Controller, a research investigation, a computer or management project or a design problem.

The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry.

The progress of the project is evaluated for internal assessment based on a minimum of three reviews. The project review committee may be constituted by the Head of the Department.The student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.

A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Total (300P) = 300 Periods

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Ability to identify, formulate, design, interpret,analyze and provide solutions to complex engineering and societal issues by applying knowledge gained on basics of science and Engineering	L6:Creating
CO2	Ability to choose, conduct and demonstrate a sound technical knowledge of their selected project topics in the field of power components, protection, high voltage, electronics, process automation, power electronics and drives, instrumentation and control by exploring suitable engineering and IT tools.	L6:Creating
CO3	Ability to understand, formulate and propose new learning algorithms to solve engineering and societal problems of moderate complexity through multidisciplinary projects understanding commitment towards sustainable development.	L2:Understanding
CO4	Ability to demonstrate, prepare reports, communicate and work in a team as a member/leader by adhering to ethical responsibilities	L6:Creating
CO5	Ability to acknowledge the value of continuing education for oneself and to stay up with technology advancements.	L5:Evaluate

<table>
<tr><td>25PTEEPE11</td><td colspan="2">NETWORK ANALYSIS AND SYNTHESIS</td><td colspan="3">SEMESTER</td><td>V</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Electric circuit Analysis</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="6">To familiarize the different methods of analysis and synthesis of electrical circuits.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT I</td><td colspan="2">S-DOMAIN ANALYSIS AND FREQUENCY DOMAIN ANALYSIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">S - domain network – driving point and transfer impedances and their properties – transform network analysis– poles and zeros of network functions – time response from pole – zero plots. Immittance –loci of RLC networks – frequency response of RLC networks – frequency response from pole – zero – bode plots.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT II</td><td colspan="2">NETWORK TOPOLOGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Network graphs, definitions, tree, co-tree, link, basic loop and basic cut sets – link currents; tie set schedules, tree branch voltages ; and cut – set schedules –incidence reduced incidence metrics – V shift and I shift – primitive impedance and admittance matrices – application to network solutions - duality and dual networks.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT III</td><td colspan="2">TWO PORT NETWORKS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Characterization of two port networks in terms of Z , Y,H and T parameters – networks equivalents – relations between network parameters –interconnections two port networks- T and π representation- Analysis of T, Ladder ,Bridged – T and lattice networks – transfer function of terminated two port networks.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT IV</td><td colspan="2">ELEMENTS OF NETWORK SYNTHESIS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Reliability of one port network – Hurwitz polynomials and properties – Positive Real functions and properties – frequency response of reactive one port – synthesis of one port network using Foster and Cauer methods - synthesis of RL, RC network using Foster and Cauer methods – synthesis of LC one port network.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>UNIT V</td><td colspan="2">DESIGN OF FILTERS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Classification of Filters – pass band and stop band filters; classification and characteristic impedance – design of constant – K, M – derived and composite filters – qualitative treatment of active filters – Butterworth and Chebyshev filters. Attenuators; T type, π type, lattice, bridged T and L type attenuators.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>1.</td><td colspan="6">Franklin F. Kuo, 'Network Analysis and Synthesis', Wiley India Private Limited, Second Edition, 2006</td></tr>
<tr><td>2.</td><td colspan="6">Sudhakar. A., and ShyammohanS Palli , 'Circuits and Networks: Analysis and Synthesis' McGraw Hill Education, New Delhi, Fifth edition, 2017.</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="6">A.Chakrabarti, 'Circuit Theory-Analysis and Synthesis', Dhanpat Rai & Co., New Delhi, Seventh revised Edition, 2018.</td></tr>
</table>

2.	Van Valkenburg, M.E., 'Network Analysis', Prentice Hall of India Private Ltd., New Delhi, Third Edition, 2014.
E- Reference:	
1.	https:// archieve.nptel.ac.in/courses/108/102/108102042/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand about time response and frequency response of electrical circuits	L2: Understanding
CO2	:	Apply graph theory to network solutions	L3: Applying
CO3	:	Characterize two port networks	L4: Analyzing
CO4	:	Choose appropriate method for network synthesis	L5: Evaluating
CO5	:	Design of filters and attenuator networks.	L6: Creating

25PTEEPE12	ADVANCED CONTROL SYSTEMS				SEMESTER			V
PREREQUISITES				**CATEGORY**	**PE**	**Credit**		**3**
Signals and Systems, Control systems				**Hours/Week**	**L**	**T**	**P**	**TH**
					3	**0**	**0**	**3**

Course Objectives:

1.	To gain knowledge in the analysis of non-linear system
2.	To gain knowledge in the analysis of digital control of linear system.

UNIT I	**NON-LINEAR SYSTEM – DESCRIPTION & STABILITY**	**9**	**0**	**0**	**9**

Linear vs non-linear – Examples – Incidental and Intentional – Mathematical description - Equilibria and linearization - Stability – Lyapunov function – Construction of Lyapunov function.

UNIT II	**PHASE PLANE AND DESCRIBING FUNCTION ANALYSIS**	**9**	**0**	**0**	**9**

Construction of phase trajectory – Isocline method – Direct or numerical integration – Describing function analysis – Computation of amplitude and frequency of oscillation.

UNIT III	**Z - TRANSFORM AND DIGITAL CONTROL SYSTEM**	**9**	**0**	**0**	**9**

Z transfer function – Block diagram – Signal flow graph – Discrete root locus – Bode plot.

UNIT IV	**STATE-SPACE DESIGN OF DIGITAL CONTROL SYSTEM**	**9**	**0**	**0**	**9**

State equation – Solutions – Realization – Controllability – Observability – Stability – Jury's test.

UNIT V	**MULTI INPUT MULTI OUTPUT (MIMO) SYSTEM**	**9**	**0**	**0**	**9**

Models of MIMO system – Matrix representation – Transfer function representation – Poles and Zeros – Decoupling – Introduction to multivariable Nyquist plot and singular values analysis – Model predictive control.

Total (45L+0T)= 45 Periods

Text Books:

1.	Benjamin C. Kuo, 'Digital Control Systems', Oxford University Press, 2010.
2.	I.J. Nagrath and M. Gopal, 'Control Systems Engineering', New Age International Publishers, 2021.

Reference Books:

1.	Raymond T. Stefani & Co., 'Design of feedback Control systems', Oxford University, 2010.
2.	George J. Thaler, 'Automatic Control Systems', Jaico Publishers, 2011.

E-Reference

1.	https://nptel.ac.in/courses/108103007
2.	https://www.google.co.in/books/edition/Advanced_Control_Systems/k7AVfjnoS7IC?hl=en&gbpv=1&dq=advanced+control+system&printsec=frontcover

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Use the conventional technique of non-linear system analysis.	L2:Understanding
CO2	:	Solve the problems in digital control systems using Z transform.	L5:Evaluating
CO3	:	Analyze discrete time systems using conventional techniques.	L3:Applying
CO4	:	Analyze the digital control system using state-space formulation.	L3:Applying
CO5	:	Know the formulation and analysis of MIMO systems.	L6:Creating

25PTEEPE13	DISCRETE CONTROL SYSTEMS			SEMESTER			V
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Control Systems			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand the digital signal processing.
2.	To study the design of sampled data control systems in state space.
3.	To impart knowledge on digital control algorithms and stability study.

UNIT I	INTRODUCTION	9	0	0	9

Review of frequency and time response analysis and specifications of continuous time systems - need for controllers - continuous time compensations - continues time PI, PD, PID controllers, Realization of basic compensators: Lag, Lead and Lag-Lead compensation schemes - problems.

UNIT II	SIGNAL PROCESSING IN DIGITAL CONTROL	9	0	0	9

Need for digital control – Configuration of basic digital control scheme – Principles of signal conversion – Basic discrete-time signals – Time domain and frequency domain models for discrete-time systems - Aliasing – Reconstruction of analog signals – Practical aspects of the choice of sampling rate – Discretization based on bilinear transformation.

UNIT III	MODELING AND ANALYSIS OF SAMPLED DATA CONTROL SYSTEM	9	0	0	9

Differential equation description – Z-transform method of description– Z-transform analysis of sampled data control systems –Jury's stability test – Routh stability criterion on the r-plane – State variable concepts: First companion – Second companion – Jordan canonical models – Discrete state variable models – Elementary principles.

UNIT IV	DESIGN OF DIGITAL CONTROL ALGORITHMS	9	0	0	9

Introduction – z-plane specifications of control system design –Digital lead, lag and lag-lead compensator design using frequency response plots - Digital lead lag compensator design using Root locus plots – z-plane synthesis – Digital controllers for deadbeat performance - Examples.

UNIT V	PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS	9	0	0	9

Development and implementation of digital PID control algorithms – Tunable PID controllers - Digital temperature control system: Control algorithm – Digital position control system: Digital measurement of shaft position/speed, control algorithm – Stepping motors and their controls: Torque-speed curves, Interfacing of stepper motors to microprocessors

Total (45L+0T)= 45 Periods

Text Books:

1.	M.Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 2009.
2.	I.J.Nagrath&M.Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 2021.

Reference Books:

1.	B.C.Kuo, Digital Control Systems,Oxford University Press,2nd Edition,2007.
2.	K. Ogata, Modern Control Engineering, Pearson Education, 2002.

3.	Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.
E-References:	
1.	https://nptel.ac.in/courses/108103008/
2.	https://www.sciencedirect.com/topics/engineering/digital-control-system

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Outline sampling techniques to control systems.	L1: Remembering
CO2	:	Design the various digital control algorithms.	L4: Analyzing
CO3	:	Predict the performance of various types of digital controllers.	L4: Analyzing
CO4	:	Identify the various types of digital compensators.	L2: Understanding
CO5	:	Illustrate applications of digital control.	L3: Applying

25PTEEPE14	BIOMEDICAL INSTRUMENTATION		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Basic Electrical and Electronics Engg, Measurements and Instrumentation		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide an adequate knowledge of the human physiology systems.
2.	To introduce different transducers for Biomedical applications.
3.	To introduce the student to the various sensing and measurement devices of bio-medical electrical systems.
4.	To provide awareness of electrical safety of medical equipment.

UNIT I	**HUMAN PHYSIOLOGICAL SYSTEMS AND BIO POTENTIAL ELECTRODES AND TRANSDUCERS**	**9**	**0**	**0**	**9**

Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – resting and action potential – bio-electric potential – nerve tissues and organs – difference systems of human body. Physiology of Human body- Brain, heart, lungs-Cardiovascular system- Respiratory system- nervous system. Design of medical instruments components of biomedical instrument systems – electrodes - transducers.

UNIT II	**BIO SIGNAL ACQUISITION BIO POTENTIAL RECORDERS**	**9**	**0**	**0**	**9**

Physiological signal amplifiers – isolation amplifiers – medical pre amplifier design – bridge amplifiers – line drive amplifiers – current amplifiers – chopper amplifiers – bio signal analysis – signal recovery and data acquisition – drift compensation in operational amplifiers – pattern recognition. Characteristics of recording system – Electrocardiography(ECG) – Electroencephalography(EEG) – Electromyography(EMG) – Electroretinography(ERG) & Electrooculography(EOG) – recorders for offline analysis.

UNIT III	**SPECIALIZED MEDICAL EQUIPMENT AND BIO-TELEMETRY**	**9**	**0**	**0**	**9**

Blood cell counter – Electron microscope – radiation detectors – photo meters and colorimeters – digital thermometer – audio meters – X-ray tube – X-ray machine – Radiography and fluoroscopy – image intensifiers – angiography – applications of X-ray examination. Biotelemetry

UNIT IV	**PHYSIOLOGICAL ASSIST DEVICES AND OPERATION THEATRE EQUIPMENT**	**9**	**0**	**0**	**9**

Pacemakers – Pacemaker batteries – artificial heart walls – Defibrillators – nerve and muscle stimulators – heart lung machine – kidney machine. Surgical diathermy – short wave diathermy – microwave diathermy – ultrasonic diathermy – therapeutic effect of heat – range and area of irritation of different diathermy techniques – Ventilators – Anesthesia machines – blood flow meters – Cardiac output measurements – Pulmonary function analyzers – Blood gas analyzers – oxymeters – elements of intensive care monitoring.

UNIT V	**SAFETY INSTRUMENTATION AND ADVANCES IN BIOMEDICAL INSTRUMENTATION**	**9**	**0**	**0**	**9**

Radiation safety instrumentation – physiological effects due to 50 Hz current passage – Micro shock and macro shock – electrical accidents in hospitals – Devices to protect against electrical hazards – hospital architecture. Computers in medicine – lasers in medicine – endoscope – Cryogenic surgery – Nuclear imaging techniques – computer tomography – thermography – ultrasonic imaging system – Magnetic resonance imaging – Positron emission tomography – digital subs traction angiography.

Total (45L+0T)= 45 Periods

Text Books:	
1.	U. Satyanarayana “Biochemistry”-5th edition – Sri Padmavathi Publications Ltd.,2017.
2.	N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: Aglobal approach”, Pearson Education Ltd, 2014.
3.	Dr.M.Arumugam, ‘Bio-Medical Instrumentation’, Anuradha Agencies, 2012.
4.	Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, ‘Bio-Medical Instrumentation and Measurements’, II edition, Pearson Education, 2011 / PHI.
Reference Books:	
1.	R.S.Khandpur, ‘Hand Book of Bio-Medical instrumentation’, Tata McGraw Hill Publishing Co Ltd.,2012.
2.	L.A. Geddes and L.E.Baker, ‘Principles of Applied Bio-Medical Instrumentation’, John Wiley &Sons, 2011.
3.	C.Rajarao, ‘Medical Instrumentation’, John Wiley & Sons,2013.
4.	C.Rajarao and S.K. Guha, ‘Principles of Medical Electronics and Bio-medical Instrumentation’, Universities press (India) Ltd, Orient Longman ltd, 2012.
E-Reference:	
1.	www.onlinecourses.nptel.ac.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Remember the purpose & methods of measurement.	L1: Remembering
CO2	:	Understand different display and recording devices for various applications.	L2: Understanding
CO3	:	Evaluate electrical & non electrical physiological measurements and bio amplifier.	L5: Evaluating
CO4	:	Apply physiological assist devices and operational theatre equipment.	L3: Applying
CO5	:	Design biomedical equipment as it is a challenging interdisciplinary process	L6: Creating

25PTEEPE15	BIOLOGY FOR ELECTRICAL ENGINEERS			SEMESTER			V
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Basic Science			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To understand biological mechanisms of living organisms from the perspective of engineers.
2.	To understanding the function and regulation of human system and acquire knowledge about biological problems that requires engineering expertise to solve them.
3.	To Understand the basics of molecular biology and genetics.
4.	To know about the cell injury and repair.
5.	To teach the microbiology and immunopathology.

UNIT I	**BIOMOLECULES AND METABOLISM**	**9**	**0**	**0**	**9**

Carbohydrates- classification - Glycolysis- definition- flow chart- steps involved in glycolysis- preparatory phase and pay off phase- kinds of reactions in glycolysis. Photosynthesis- definition- significance photosynthetic- pigments types.

UNIT II	**BASICS OF ENZYMES, MACROMOLECULES AND NUCLEIC ACIDS**	**9**	**0**	**0**	**9**

Proteins- classification- structure of proteins - properties of proteins- protein synthesis. Types-Structural components of nucleic acids- acid, pentose sugar and nitrogenous base- nucleoside – nucleotide and its functions - single and double helical structure of DNA-comparison between DNA and RNA- types of RNA -mRNA, tRNA and rRNA and their function.

UNIT III	**FUNDAMENTALS OF BIOCHEMISTRY**	**9**	**0**	**0**	**9**

Introduction to Biochemistry, water as a biological solvent, weak acid and bases, pH, buffers, Energy in living organism. Properties of water and their applications in biological systems. Introduction to Biomolecules, Biological membrane, Clinical application of Electrolytes and radioisotopes.

UNIT IV	**CELL DEGENERATION, REPAIR AND NEOPLASIA**	**9**	**0**	**0**	**9**

Cells and their structure – Cell injury - cellular adaptations of growth and differentiation, Inflammation and Repair including fracture healing, Neoplasia, Classification, Benign and Malignant tumours, carcinogenesis, spread of tumours Autopsy and biopsy.

UNIT V	**FUNDAMENTALS OF MICROBIOLOGY AND IMMUNOPATHOLOGY**	**9**	**0**	**0**	**9**

Structure of Bacteria and Virus - Morphological features and structural organization - List of common bacterial, fungal and viral diseases of human beings. Basics of Microscopes : Light microscope, Electron microscope (TEM & SEM). - Natural and artificial immunity - Immunological techniques: immune diffusion, immuno electrophoresis, RIA and ELISA, monoclonal antibodies.

Total (45L+0T)= 45 Periods

Text Books:

1.	FJ.L.Jain, Sanjay jain and Nitin jain- “Fundamentals of Biochemistry” - Sixth edition, S.Chand and company Ltd., Ram nagar, 2005.
2.	Dr.A.V.S.S.Rama Rao-“ Text book of Biochemistry”- Text book of Biochemistry- First edition- UBS Publishers' Distributors Pvt. Ltd., 2008

3.	U. Satyanarayana –" Biochemistry"-5th edition – Sri Padmavathi Publications Ltd.,2017.
4.	N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, "Biology: A global approach", Pearson Education Ltd, 2014.
5.	RAFI MD "Text book of biochemistry for Medical Student" Fourth Edition, Universities Press, Orient Blackswan Private Limited - New Delhi 2021.
6.	Dubey RC and Maheswari DK. "A Text Book of Microbiology" Chand & Company Ltd, 2007 4.
7.	Prescott, Harley and Klein, "Microbiology", 10th edition, McGraw Hill, 2017
Reference Books:	
1.	Stent, G. S.; and Calender-" Molecular Genetics"- Second edition - R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
2.	By Nelson, D. L.; and Cox- "Principles of Biochemistry"- V Edition- M. M.W.H. Freeman and Company
3.	Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H-" Outlines of Biochemistry"- John Wiley and Sons
4.	Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, 'Biological Science', Pearson Education India, 2016.
5.	Reinhard Renneberg, Viola Berkling and Vanya Loroch, 'Biotechnology for Beginner's', Academic Press, 2017.
6.	S Balaji, S Lakshminarayanan, "Conceptual comparison of metabolic pathways with electronic circuits", Journal of Bionics Engineering, Vol 1, Issue 3, pg 175-182, 2004
E-Reference	
1	www.onlinecourses.nptel.ac.in/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Be aware that all types of life have the identical structural units.	L1: Remembering
CO2	:	Explain, analyze, diagnose, and develop new therapies to treat disease and heal damaged tissues and organ systems.	L4: Analyzing
CO3	:	Teach the fundamentals of microbiology and immunopathology.	L3: Applying
CO4	:	Explain human biological systems.	L3: Applying
CO5	:	Share knowledge in genetics and molecular biology.	L2: Understanding

25PTEEPE16	ADAPTIVE CONTROL		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Control systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on how to recursively estimate the parameters of discrete input– output models using recursive parameter estimation methods
2.	To make the student understand the principles of STR, MRAC and Gain scheduling.
3.	To make the student design simple adaptive controllers for linear systems using STR, MRAC and Gain scheduling

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications-Parameter estimation: -LS, RLS: and ERLS.

UNIT II	**GAIN SCHEDULING**	**9**	**0**	**0**	**9**

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback.

UNIT III	**DETERMINISTIC SELF-TUNING REGULATORS**	**9**	**0**	**0**	**9**

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics

UNIT IV	**STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS**	**9**	**0**	**0**	**9**

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators

UNIT V	**MODEL – REFERENCE ADAPTIVE SYSTEM**	**9**	**0**	**0**	**9**

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory – Design of MRAS using Lyapunov theory – Relations between MRAS and STR.

Total (45L+0T)= 45 Periods

Text Books:

1.	K.J. Astrom and B. J. Wittenmark, "Adaptive Control", Second Edition, Pearson Education Inc., Second Edition, 2013.

Reference Books:

1.	T. Soderstorm and Petre Stoica, "System Identification", Prentice Hall International (UK) Ltd., 1989, 1st Edition.
2.	Lennart Ljung, "System Identification: Theory for the User", Second Edition, Prentice Hall, 1999.

E-references:	
1.	https://archive.nptel.ac.in/courses/108/102/108102113/
2.	https://in.mathworks.com/help/slcontrol/adaptive-control-design.html
3.	https://in.mathworks.com/videos/nonlinear-model-based-adaptive-robust-controllerin-an-oil-and-gas-wireline-operation-1637577967956.html
4.	https://www.dynalog-us.com/adaptive-robot-control.htm
5.	https://www.vlab.co.in/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Ability to apply the estimation algorithm to estimate the parameters of the process.	L3: Applying
CO2	:	Ability to apply the adaptive control concepts to control a process.	L3: Applying
CO3	:	Use appropriate software tools for design of adaptive controllers and analysis of the process.	L5: Evaluating
CO4	:	Identify, formulate, carry out research by designing suitable adaptive schemes for complex instrumentation problem.	L5: Evaluating
CO5	:	Apply the concepts/techniques to design adaptive control for multidisciplinary problem	L3: Applying

25PTEEPE21	HVDC TRANSMISSION SYSTEMS			SEMESTER		V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power System Generation, Transmission and Distribution Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concept, planning of DC power transmission and comparison with AC power transmission.
2.	To analyze the converters used in HVDC system.
3.	To study about the HVDC system control.
4.	To understand the reactive power requirements of the converter and Static VAR control methods.
5.	To understand the harmonics generation in HVDC system and design of harmonics filters.
6.	To impart knowledge on modelling and analysis of HVDC systems.

UNIT I	**DEVELOPMENT OF HVDC TECHNOLOGY**	**9**	**0**	**0**	**9**

Introduction – Comparison of AC and DC transmission – Applications of DC transmission – HVDC system configurations and components – Planning for HVDC transmission – Modern trends in HVDC technology - DC breaker - Operating problems - HVDC transmission based on voltage source converter - MTDC System: types and applications

UNIT II	**ANALYSIS OF HVDC CONVERTERS**	**9**	**0**	**0**	**9**

Line commutated converter - Pulse number – Choice of best topology for HVDC – Analysis of six pulse bridge converter without overlap, and with overlap less than 60˚ - Equivalent circuit model - Converter bridge characteristics – Analysis of 12 pulse converters - Analysis of Capacitor Commutated Converter (CCC) - Analysis of VSC based HVDC Converter.

UNIT III	**CONTROL OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**

Basic principles of DC link control – Converter control characteristics – System Control Hierarchy – Firing angle control – Current and Extinction angle control – Starting and stopping of DC link and power control – Higher level controllers – Control of VSC based HVDC link.

UNIT IV	**REACTIVE POWER CONTROL, HARMONICS AND FILTERS**	**9**	**0**	**0**	**9**

Reactive power requirements in steady state – Sources of reactive power – SVC and STATCOM.
Generation of Harmonics: characteristic and non-characteristics harmonics – Troubles caused by harmonics - Design of AC filters – Design of DC Filters –Active filters.

UNIT V	**MODELLING AND ANALYSIS OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**

System models: converter – converter controllers – DC networks and AC networks; System simulation: Philosophy and tools – Physical model (HVDC simulator) and Parity simulator – Modelling of DC systems for digital dynamic simulation - Transient simulation of DC and AC networks.

Total (45L+0T)= 45 Periods

Text Books:

1.	Padiyar, K.R., “HVDC Power Transmission Systems”, New Age International Publishers, New Delhi, Third Edition, 2015.
2.	Edward Wilson Kimbark, “Direct Current Transmission”, Vol. I, Wiley Interscience, New York, 1971.

Reference Books:

1.	Colin Adamson and N.G.Hingorani, “High Voltage Direct Current Power Transmission”, Garraway Limited, London, First edition, 1960.
2.	Arrillaga, J., “HVDC Transmission”, Peter Peregrinus, London, 1983

3.	Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 2004.
4.	Kamakshaiah, S. & Kamaraju, V, "HVDC Transmission", First Edition, Tata McGraw Hill, 2011.
E-Reference:	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Outline the concept of HVDC technology and MTDC systems.	L2: Understanding
CO2	:	Analyze the converters used in HVDC system	L4: Analyzing
CO3	:	Acquire knowledge about basic principles of HVDC system control	L2: Understanding
CO4	:	Design of static VAR systems for reactive power control and filters for harmonic mitigation in HVDC system.	L3: Applying
CO5	:	Develop the modelling and Analysis of HVDC systems.	L4: Analyzing

25PTEEPE22	EHVAC TRANSMISSION SYSTEMS			SEMESTER		V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To emphasize the fundamental concept of EHVAC transmission, electrostatic effects, corona effects and voltage controller for an EHVAC transmission system

UNIT I	INTRODUCTION	9	0	0	9

Necessity of EHV AC transmission, benefits and challenges, power handling capacity and line losses, mechanical considerations, resistance of conductors, temperature rise of conductors and current-carrying capacity, properties of bundled conductors – numerical problems.

UNIT II	LINE AND GROUND REACTIVE PARAMETERS	9	0	0	9

Inductance of EHV line configurations, line capacitance calculation, sequence inductances and capacitances, line parameters for modes of propagation, resistance and inductance of ground return.

UNIT III	VOLTAGE GRADIENTS OF CONDUCTORS	9	0	0	9

Electrostatics, field of sphere gap, field of line changes and properties, charge – potential relations for multi-conductors lines, surface voltage gradient on conductors, distribution of voltage gradient on sub-conductors of bundle, effect of high electro static field on humans, animals and plants.

UNIT IV	CORONA EFFECTS	9	0	0	9

Power loss and corona loss, charge-voltage (q–V) diagram and corona loss, attenuation of travelling waves due to corona loss, audible noise: generation and characteristics, limits for audible, audible noise measurement and meters, formulae for audible noise and its use in design, relation between single-phase and three-phase AN levels example

UNIT V	POWER FREQUENCY VOLTAGE CONTROL	9	0	0	9

Power circle diagram and its use - voltage control using synchronous condensers - cascade connection of shunt and series compensation - sub synchronous resonance in series capacitor - compensated lines - static VAR compensating system

Total (45L + 0T) = 45 Periods

Text Books:

1.	R. D. Begamudre, “EHVAC Transmission Engineering” New Age International (P)Ltd., Fourth Edition, 2011.
2.	Sunil. S. Rao,“HVAC and DC Transmission practice”, Khanna Publishers, Delhi, 2023.

Reference Books:

1.	Shobhit Gupta and Deepak Gupta,“ EHV AC/DC Transmission Engineering Books Publishers, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Summarize the trends in EHVAC Transmission and calculate Line inductance and capacitances of bundled conductors.	L2: Understanding
CO2	:	Analyze the transmission line parameters.	L4: Analysing
CO3	:	Recall the electrostatic effects and corona effects.	L1: Remembering
CO4	:	Select the appropriate voltage control devices.	L4: Analysing
CO5	:	Apply the compensation techniques.	L3: Applying

25PTEEPE23	FLEXIBLE AC TRANSMISSION SYSTEMS			SEMESTER			V
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the reactive power control techniques.
2.	To educate on static VAr compensators and their applications
3.	To provide knowledge on thyristor controlled series capacitors
4.	To study about STATCOM devices
5.	To acquire knowledge on FACTS controllers

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Reactive Power Control in Electrical Power Transmission Lines -Uncompensated Transmission Line – Series Compensation – Basic Concepts of Static Var Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC).

UNIT II	**STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS**	**9**	**0**	**0**	**9**

Voltage Control by SVC – Advantages of Slope in Dynamic Characteristics – Influence of SVC on System Voltage – Design of SVC Voltage Regulator –Modelling of SVC for Power Flow and Fast Transient Stability – Applications: Enhancement of Transient Stability – Steady State Power Transfer – Enhancement of Power System Damping.

UNIT III	**THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS**	**9**	**0**	**0**	**9**

Operation of the TCSC – Different Modes of Operation – Modelling of TCSC – Variable Reactance Model – Modelling for Power Flow and Stability Studies. Applications: Improvement of the System Stability Limit – Enhancement of System Damping

UNIT IV	**VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

STATCOM – Principle of Operation – V-I Characteristics. Applications: Steady State Power Transfer-Enhancement of Transient Stability – Prevention of Voltage Instability. SSSC-Operation of SSSC and the Control of Power Flow –Modelling of SSSC In Load Flow and Transient Stability Studies.

UNIT V	**CO-ORDINATION OF FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

Controller Interactions – SVC – SVC Interaction – Co-ordination of Multiple Controllers using Linear Control Techniques – Control Coordination using Genetic Algorithm.

Total (45L+0T)= 45 Periods

Text Books:

1.	R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers For Electrical Transmission Systems", IEEE Press And John Wiley & Sons, Inc, 2002.
2.	Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2011.
3.	K.R.Padiyar, " FACTS Controllers in Power Transmission and Distribution", New Age International Publishers New Delhi, second edition, 2016

Reference Books:	
1.	A.T.John, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2.	V.K.Sood,”HVDC And FACTS Controllers – Applications of Static Converters in Power System”, APRIL 2004 , Kluwer Academic Publishers, 2004.
3.	Xiao – Ping Zang, Christian Rehtanz And Bikash Pal, “Flexible AC Transmission System: Modelling and Control” Springer, 2012.
E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Identify suitable compensator for reactive power compensation.	L3: Applying
CO2	:	Analyse the impacts in network operations due to SVC placement.	L4: Analyzing
CO3	:	Visualise the significance of TCSC in network operation.	L3: Applying
CO4	:	Evaluate the performance of steady state and transients of FACTS controllers.	L5: Evaluating
CO5	:	Elaborate the features of coordination of FACTS controllers.	L3: Applying

25PTEEPE24	POWER SYSTEM OPERATION AND CONTROL		SEMESTER			V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems; Power System Analysis and Stability		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To familiarize the significance of power system operation and control.
2. To understand the concepts of real power – frequency control, and reactive power – voltage control.
3. To acquire knowledge on economic power system operations, and computer aided control of power system.

UNIT I	OVERVIEW OF POWER SYSTEM OPERATION AND CONTROL	9	0	0	9

Power scenario in Indian grid – National and Regional load dispatching centers – requirements of good power system - necessity of voltage and frequency regulation. System load variation: System load characteristics, load curves -daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed, spinning, cold and hot reserves. Basic concepts of economic dispatch, unit commitment, load shedding and islanding, deregulation, governor control, LFC, AVR, system voltage control and security control - Tariff: characteristics and types.

UNIT II	REAL POWER - FREQUENCY CONTROL	9	0	0	9

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases; Multi-area systems: Two-area system modeling: static analysis, uncontrolled case, tie-line with frequency bias control; state variable model- integration of economic dispatch control with LFC.

UNIT III	REACTIVE POWER–VOLTAGE CONTROL	9	0	0	9

Generation and absorption of reactive power - basics of reactive power control – Automatic Voltage Regulator (AVR) – brushless AC excitation system – block diagram representation of AVR loop - static and dynamic analysis – stability compensation – voltage drop in transmission line - methods of reactive power injection - tap changing transformer, SVC and STATCOM for voltage control.

UNIT IV	ECONOMIC DISPATCH AND UNIT COMMITMENT	9	0	0	9

Statement of economic dispatch problem - input and output characteristics of thermal plant Incremental cost curve, co-ordination equations with and without loss, solution by direct method and Lambda -iteration method (No derivation of loss coefficients)- Base point and participation factors method.

Statement of Unit Commitment problem- Constraints in Unit Commitment: spinning reserve- thermal unit constraints- hydro constraints- fuel constraints and other constraints; Unit Commitment solution methods: Priority-list methods, forward dynamic programming approach, numerical problems only in priority-list method using full-load average production cost.

UNIT V	COMPUTER CONTROL OF POWER SYSTEMS	9	0	0	9

EMS functions - Energy control centre functions: Monitoring, data acquisition and control, energy control centre levels - SCADA: system hardware configuration –master station-remote terminal units- and functions; Network topology determination- state estimation, security analysis and control - Various operating states: normal, alert, emergency, extremis and restorative; State transition diagram showing various state transitions and control strategies.

Total (45 L + 0 T) = 45 Periods

Text Books:

1.	Allen J. Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", Wiley India Ltd, New Delhi, Second Edition, Reprint 2016.
2.	Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, 34th reprint 2010.
3.	Kundur. P, "Power System Stability & Control", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint 2010.
Reference Books:	
1.	Kothari, D.P., and Nagrath, I.J., "Modern Power System Analysis", Fourth, Tata McGraw Hill Education Pvt., Limited, New Delhi, 2011.
2.	Grigsby, L.L.,"The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
3.	Weedy, B.M. and Cory, B.J., "Electric Power systems", Wiley, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize the fundamentals of power system operation and control.	L2: Understanding
CO2	:	Interpret the control action to meet the real power demand variations.	L3: Applying
CO3	:	Employ the reactive power injections for voltage profile improvement.	L3: Applying
CO4	:	Formulate the economic scheduling problems in power system.	L4: Analysing
CO5	:	Examine the need of computer aided control for power system operations and control.	L4: Analysing

<table>
<tr><td colspan="2">25PTEEPE25</td><td colspan="2">UNDERGROUND CABLE ENGINEERING</td><td colspan="3">SEMESTER</td><td>V</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">Power Generation, Transmission and Distribution Systems .</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Objectives: To impart knowledge on the following topics</td></tr>
<tr><td>1.</td><td colspan="7">Understanding Power Cable Characteristics and Applications.</td></tr>
<tr><td>2.</td><td colspan="7">Cable Manufacturing.</td></tr>
<tr><td>3.</td><td colspan="7">Installation of Underground power cables.</td></tr>
<tr><td>4.</td><td colspan="7">Underground cable System Fault Locating.</td></tr>
<tr><td>5.</td><td colspan="7">Testing and maintenance of Underground cable system.</td></tr>
<tr><td>6.</td><td colspan="7">Cable Performance and Field Assessment of Power Cables.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT I</td><td colspan="2">INTRODUCTION TO ELECTRICAL POWER CABLES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Development of Underground Cables - Electric Lighting- Distribution of Energy for Lighting- - Paper Insulated Cables - Underground Residential Distribution Systems- Medium Voltage Cable Development.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT II</td><td colspan="2">CABLE ARCHITECTURE, DIELECTRIC THEORY AND CABLE CHARACTERISTICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Architecture of Underground Cabling System - Basic Dielectric Theory of Cable – Conductors -Armour and Protective Finishes - Cable Characteristics: Electrical- Fundamentals of Electrical Insulation Materials - Electrical Properties of Cable Insulating Materials - Cable Standards and Quality Assurance - Cable design parameters- Current Carrying Capacity - Short-circuit Ratings.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT III</td><td colspan="2">SUPPLY DISTRIBUTION SYSTEMS AND CABLES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Supply Distribution Systems - Distribution Cable Types, Design and Applications – Paper Insulated Distribution Cables - PVC Insulated Cables - Polymeric Insulated Distribution Cables for 6-30 kV - Manufacture of Distribution Cables - Joints and Terminations for Distribution Cables - Testing of Distribution Cables</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT IV</td><td colspan="2">TRANSMISSION SYSTEMS AND CABLES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Basic Cable Types for A.C. Transmission - Self-contained Fluid-filled Cables – Gas Pressure Cables - High Pressure Fluid-filled Pipe Cables - Polymeric Insulated Cables for Transmission Voltages - Techniques for Increasing Current Carrying Capacity - Transmission Cable Accessories and Jointing for Pressure-assisted and Polymeric cables.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">UNIT V</td><td colspan="2">CABLE INSTALLATION, TESTING, MAINTENANCE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Installation of Transmission Cables -Splicing, Terminating, and Accessories – Sheath Bonding and Grounding-Testing of Transmission Cable Systems - Underground System Fault Locating - Field Assessment of Power Cable Systems- Condition monitoring tests – PD measurements.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8" align="right">Total (45L+0T)= 45 Periods</td></tr>
<tr><td colspan="8">Text Books:</td></tr>
<tr><td>1.</td><td colspan="7">William Thue, ‘Electrical Power Cable Engineering’, CRC Press Taylor & Francis Group., 6000 Broken Sound Parkway NW, Suite 300Boca Raton, FL 33487-2742, 3rd Edition, 2017.</td></tr>
<tr><td>2.</td><td colspan="7">G. F. Moore, ‘Electric Cables Handbook’ -Third edition, Blackwell Science Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK., January 2017.</td></tr>
</table>

Reference Books:	
1.	Leonard L. Grigsby, ‘Electrical Power Cable Engineering’ - CRC Press, Marcel Dekker, 3rd Edition 2012.
2.	Christian Flytkjaer Jensen, Online Location of Faults on AC Cables in Underground Transmission Systems (Springer Theses), 2014, March.
3.	https://kafactor.com/content/technical-resources/kerite-underground-cable-engineeringhandbook.Pdf
4.	Handbook on Cable Fault Localization (April 2020) https://rdso.indianrailways.gov.in/works/uploads/File/Handbook%20on%20Cable%20Fault%20Localization(2).pdf
5.	K. H. Ali et al.: Industry Practice Guide for Underground Cable Fault-Finding in the LVDN: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9807279, June 2022.
6.	R. W. Deltenre, J. J. Schwarz, and H. J. Wagnon, ‘‘Underground cable fault location: A handbook to TD-153,’’ BDM Corp., Albuquerque, NM, USA, Final Rep. EPRI EL-363, 1977. [Online]. Available: https://www.osti.gov/servlets/purl/7233049, doi: 10.2172/7233049, January 1997

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the fundamentals of underground cable system.	L1: Understanding
CO2	:	Gain knowledge on the architecture of UG cable and physical and electrical characteristics of the UG cable.	L4: Analyzing
CO3	:	Understand different types of cable used in distribution system.	L2: Understanding
CO4	:	Acquire knowledge on Underground cables used in transmission system.	L3: Applying
CO5	:	Understand the cable installation, theory/methodology of testing and maintenance.	L3: Applying

25PTEEPE26	POWER SYSTEM STATE ESTIMATION AND SECURITY CONTROL			SEMESTER			V
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System; Power System Analysis and Stability			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To acquire fundamental knowledge on power system state estimation.
2.	To familiarise on network observability analysis.
3.	To get conceptual aspects in power system state estimation and strategies to enhance the secure power system operations.

UNIT I	INTRODUCTION	9	0	0	9
State estimation- Energy management system- SCADA system- Energy control centers- Security monitoring and control- Concepts of reliability, security and stability - State transitions and control strategies- Data acquisition systems - Modulation techniques, MODEMS, Power line carrier communication.					
UNIT II	**POWER SYSTEM STATE ESTIMATION**	**9**	**0**	**0**	**9**
Static state estimation: Active and reactive power bus measurements – Line flow measurements - Line current measurements – Bus voltage measurements - Measurement model and assumptions - Weighted least square state estimation algorithm- Maximum likelihood estimation - Decoupled formulation of WLS state estimation- Fast decoupled state estimation.					
UNIT III	**NETWORK OBSERVABILITY ANALYSIS**	**9**	**0**	**0**	**9**
Tracking state estimation: Algorithm - Computational aspects – Measurement redundancy - Accuracy and variance of measurements - Variance of measurement residuals- Detection, identification and suppression of bad measurements - Pseudo measurements- Virtual measurements- External system equivalencing- Network observability - Observability analysis using phasor measurement units.					
UNIT IV	**DISTRIBUTION SYSTEM STATE ESTIMATION**	**9**	**0**	**0**	**9**
Distribution system state estimation- State of the art methods – Comparison of different DSSE algorithms- Developments in measurement system and DSSE design- Pseudo measurements- System architecture.					
UNIT V	**SECURITY ASSESSMENT AND ENHANCEMENT**	**9**	**0**	**0**	**9**
Contingency analysis: Linearized AC and DC models of power systems for security assessment - Line outage distribution factors and generation shift factors for DC and linearized AC models - Single contingency analysis using these factors. Contingency ranking and security indices-Correcting the generator dispatch for security enhancement using linearized DC models – Methods using sensitivity factors - Compensated factors. Emergency and restorative control procedures.					
	Total (45 L + 0 T)= 45 Periods				

Text Books:

1.	Ali Abur, “Power System State Estimation Theory and Implementation”, Marcel Dekker, 2004.
2.	Wood, A.J., Wollenberg, B.F., and Sheble, G.B., “Power Generation, Operation and Control”, John Wiley and Sons, 3rd Edition, 2013.

3.	Mahalanabis, Kothari and Ahson, "Computer Aided Power System Analysis and Control", Tata McGraw Hill Publishers, 1991.
Reference Books:	
1.	Abhijit Chakrabarti and Sunita Halder, "Power System Analysis Operation and Control", PHI Learning, 2010.
2.	G.L. Kusic, "Computer Aided Power System Analysis", Prentice Hall of India, 1989.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the conceptual aspects in power system state estimation.	L2: Understanding
CO2	:	Demonstrate various state estimation methods.	L3: Applying
CO3	:	Acquire proficiency to perform observability analysis.	L4: Analysing
CO4	:	Demonstrate the distribution state estimation.	L3: Applying
CO5	:	Realize the security assessment and enhancement strategies.	L3: Applying

25PTEEPE31	DIGITAL SIGNAL PROCESSING		SEMESTER			VI
PREREQUISITES		CATEGORY	PE	Credit		3
Signals and Systems, and Control systems		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To classify signals and systems & their mathematical representation.
2.	To analyze the discrete time systems.
3.	To study about filters and their design for digital implementation.

UNIT I	INTRODUCTION	9	0	0	9

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

UNIT II	DISCRETE TIME SYSTEM ANALYSIS	9	0	0	9

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z transform, application to discrete systems - Stability analysis, frequency response – Convolution – Introduction to Fourier transform – Discrete time Fourier transform.

UNIT III	DISCRETE FOURIER TRANSFORM AND COMPUTATION	9	0	0	9

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

UNIT IV	DESIGN OF DIGITAL FILTERS	9	0	0	9

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. Analog filter design – Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation – Warping, Prewarping – Frequency transformation.

UNIT V	DIGITAL SIGNAL PROCESSORS	9	0	0	9

Introduction – Architecture of one DSP processor for motor control – Features – Addressing Formats – Functional modes - Introduction to Commercial Processors.

Total (45L+0T)= 45 Periods

Text Books:

1.	J.G. Proakis and D.G. Manolakis, ‘Digital Signal Processing Principles, Algorithms and Applications’, Pearson Education, New Delhi, 2006.
2.	Robert Schilling & Sandra L.Harris, Introduction to Digital Signal Processing using Matlab”, Cengage Learning, 2014.
3.	B. Venkataramani, M. Bhaskar, “Digital Signal Processor, Architecture, Programming and Application”, Tata McGram Hill, New Delhi, 2003.

Reference Books:

1.	Emmanuel C Ifeachor and Barrie W Jervis, “Digital Signal Processing Principles – A Practical approach” Pearson Education, Second edition
2.	Alan V. Oppenheim, Ronald W. Schafer and John R. Buck, “ Discrete – Time Signal Processing”, Pearson Education, New Delhi , 2003.
3.	Sen M.kuo, woonseng.S.gan, “Digital Signal Processors, Architecture, Implementations & Applications, Pearson,2013.
4.	S.K. Mitra, ‘Digital Signal Processing – A Computer Based Approach’, McGraw Hill Edu, 2013.

E-Reference	
1.	https://nptel.ac.in/courses/108105055/34
2.	https://books.google.co.in/books?isbn=8131710009

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the types of systems and signals.	L2: Understanding
CO2	:	Solve problems in digital system using Z transform.	L5: Evaluating
CO3	:	Apply Fourier transforms for processing of digital signals.	L3: Applying
CO4	:	Analyze digital systems using Fast Fourier transform.	L3: Applying
CO5	:	Design digital filters algorithms in digital signal processor platforms	L5: Evaluating

25PTEEPE32	EMBEDDED SYSTEM DESIGN			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Microprocessor and Microcontroller, C programming			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To acquaint the students the building blocks of embedded system, selection of various components for building an embedded system.
2.	To understand different communication protocols used in embedded system
3.	To study the different programming techniques used in embedded system software engineering
4.	To understand the concepts of operating systems that are exclusively used in embedded systems.

UNIT I	**INTRODUCTION TO EMBEDDED SYSTEM**	**9**	**0**	**0**	**9**

Introduction to functional building blocks of embedded systems – Embedded Hardware Core - Bus Structure - Block Diagram of Embedded System - a Microprocessor-Based System – a Microcontroller-Based System – DSP - Register, memory devices, ports, timer, interrupt controllers.

UNIT II	**PROCESSOR AND MEMORY ORGANIZATION**	**9**	**0**	**0**	**9**

Structural units in a processor; selection of processor and memory devices; shared memory; DMA; interfacing processor, memory and I/O units; memory management – Cache mapping techniques, dynamic allocation - Fragmentation.

UNIT III	**DEVICES AND BUSES**	**9**	**0**	**0**	**9**

Timers, Counters, serial communication using I2C, CAN, USB buses- parallel communication using ISA, PCI, PCI/X buses; interfacing with devices/ports, device drivers in a system – Serial port & parallel port.

UNIT IV	**EMBEDDED PROGRAMMING**	**9**	**0**	**0**	**9**

Structure of Embedded C Program, C Program build process, Type, Storage Class and Scope of Variables, Building a C Program, Bitwise operations, Pointer variables and memory addresses, Functions and structures, Pointers to functions and structures, Interrupt functions in C program

UNIT V	**REAL TIME OPERATING SYSTEM RTOS**	**9**	**0**	**0**	**9**

Introduction to basic concepts of RTOS, Context switching, pre-emptive & non-pre-emptive multitasking, semaphores - Scheduling – Thread states, pending threads, context switching, round robin scheduling, priority based scheduling, assigning priorities, deadlock, watch dog timers. –Interrupt handling, task scheduling; embedded system design issues in system development process – Action plan, use of target system, emulator, use of software tools

Total (45L+0T) = 45 Periods

Text Books:

1.	Daniel W. Lewis “Fundamentals of Embedded Software”, Prentice Hall of India, 2004.
2.	James K. Peckol – “Embedded System - A Contemporary Design Tool”, John Wiley, 2nd Edition, 2019
3.	Steve Heath, “Embedded System Design”, II edition, Elsevier, 2003.
4.	David E. Simon, “An Embedded Software Primer”, Pearson Education, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concepts of Embedded Systems.	L2: Understanding
CO2	:	Appreciate the general organization of Embedded Systems	L1: Remembering
CO3	:	Understand various devices required for an Embedded System Design	L2: Understanding
CO4	:	Understand the implementation of Programming techniques for Embedded System	L3: Applying
CO5	:	Know the various blocks of RTOS and its implementation in Design	L5: Evaluating

25PTEEPE33	ARTIFICIAL INTELLIGENCE AND COMPUTER VISION		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Soft computing		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the various characteristics of Intelligent agents
2.	To learn the different search strategies in AI
3.	To learn to represent knowledge in solving AI problems
4.	To understand the different ways of designing software agents
5.	To know about the various applications of AI
6.	To provide introduction to computer vision

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction-Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents – Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

UNIT II	**PROBLEM SOLVING METHODS**	**9**	**0**	**0**	**9**

Problem solving Methods – Search Strategies – Uninformed – Informed – Heuristics – Local Search Algorithms and Optimization Problems – Searching with Partial Observations – Constraint Satisfaction Problems – Constraint Propagation – Backtracking Search – Game Playing – Optimal Decisions in Games – Alpha – Beta Pruning – Stochastic Games

UNIT III	**KNOWLEDGE REPRESENTATION**	**9**	**0**	**0**	**9**

First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining – Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering – Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories – Reasoning with Default Information

UNIT IV	**SOFTWARE AGENTS AND AI APPLICATIONS**	**9**	**0**	**0**	**9**

Architecture for Intelligent Agents – Agent communication – Negotiation and Bargaining – Argumentation among Agents – Trust and Reputation in Multi-agent systems.

AI applications: Language Models – Information Retrieval – Information Extraction – Natural Language Processing – Machine Translation – Speech Recognition – Robot – Hardware –Perception – Planning – Moving.

UNIT V	**COMPUTER VISION**	**9**	**0**	**0**	**9**

Digital Image Processing: Image formation –image filtering- Edge detection- principal component analysis-corner detection – SIFT –Large scale image search application

Geometric techniques in computer vision: Image transformations – Camera projections- camera calibration – Depth from stereo – two view structure from motion- object tracking

Machine learning for computer vision: introduction to machine learning-Image classification – object detection – semantic segmentation

Total (45L+0T)=45 Periods

Text Books:	
1.	S. Russel and P. Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, Third Edition, 2009.
2.	I. Bratko, “Prolog: Programming for Artificial Intelligence” , Fourth Edition, Addison-Wesley Education Publishers Inc., 2011.
3	David A. Forsyth and Jean Ponce, “Computer Vision: A Modern Approach”, Pearson Publications, Second Edition, 2012.
4	Richard Hartley and Andrew Zisserman, ”Multiple View Geometry in Computer Vision”, Cambridge University Press , Second Vision, 2004.

Reference Books:	
1.	M. Tim Jones,” Artificial Intelligence: A systems Approach (Computer science)”, Jones and Bartlett Publishers Inc., First Edition, 2008.
2.	Nils J.Nilsson,” The Quest for Artificial Intelligence”, Cambridge University Press, 2009.
3.	William F. Clocksin and Christopher S. Mellish, “Programming in Prolog: Using ISO standard”, Fifth Edition, Springer , 2003.
4.	Gerhard Weiss, “ Multi Agent systems”, Second Edition, MIT Press, 2013.
5.	David L. Poole and Alan K.Mackworth, “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press 2010.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Use appropriate search algorithms for any AI problem	L3: Applying
CO2	:	Represent using first order and predicate logic	L2: Understanding
CO3	:	Provide the apt agent strategy to solve a given problem	L4: Analyzing
CO4	:	Use Artificial Intelligence for various application	L3: Applying
CO5	:	Understand to use AI techniques in computer vision	L2: Understanding

25PTEEPE34	SOFT COMPUTING TECHNIQUES			SEMESTER		VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Mathematics, ‘C’ Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide Basics of artificial neural network.
2.	To provide adequate knowledge of genetic algorithms and its application to economic dispatch and unit commitment problems
3.	To expose the students to the features of hybrid control systems

UNIT I	ARTIFICIAL NEURAL NETWORK	9	0	0	9

Review of fundamentals – Biological neuron, artificial neuron, activation function, and single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network – online learning algorithms, BP through time – RTRL algorithms – Reinforcement learning.

UNIT II	NEURAL NETWORKS FOR MODELLING AND CONTROL	9	0	0	9

Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller – Familiarization with neural network toolbox.

UNIT III	FUZZY SET THEORY	9	0	0	9

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno), equilibrium points, aggregation, projection, composition, cylindrical extension, fuzzy relation – Fuzzy membership functions.

UNIT IV	FUZZY LOGIC FOR MODELLING AND CONTROL	9	0	0	9

Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems – Familiarization with fuzzy logic toolbox.

UNIT V	HYBRID CONTROL SCHEMES	9	0	0	9

Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– GA – Optimization of membership function and rule base using Genetic Algorithm – Introduction to other evolutionary optimization techniques, support vector machine– Case study – Familiarization with ANFIS toolbox.

Total (45L+0T)= 45 Periods

Text Books:

1.	Laurance Fausett, Englewood cliffs, N.J., ‘Fundamentals of Neural Networks’, Pearson Education, 1992
2.	S.N.Sivanandam and S.N.Deepa,’ Principles of Soft computing, Wiley India Edition, 2nd Edition, 2013
3.	Timothy J. Ross, ‘Fuzzy Logic with Engineering Applications’, Tata McGraw Hill, 1997.

Reference Books:

1.	Simon Haykin, ‘Neural Networks’, Pearson Education, 2003.
2.	Hagan, Demuth, Beale, “ Neural Network Design”, Cengage Learning, 2012.

3.	N.P.Padhy, " Artificial Intelligence and Intelligent Systems", Oxford, 2013.
4.	Millon W.T., Sutton R.S. and Webrose P.J., "Neural Networks for Control", MIT press, 1992
5.	Goldberg, "Genetic Algorithm in Search, Optimization and Machine learning", Addison Wesley Publishing Company Inc. 1989
E-Reference	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Ability to understand and apply basic Artificial neural network.	L2: Understanding
CO2	:	To understand and apply modelling and control of neural network.	L3: Applying
CO3	:	To remember modelling and control of fuzzy control systems.	L1: Remembering
CO4	:	Evaluate hybrid control schemes.	L5: Evaluating
CO5	:	Design a fuzzy controller.	L6: Creating

25PTEEPE35	INTERNET OF THINGS FOR ELECTRICAL SYSTEM			SEMESTER		VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Microprocessors and microcontrollers		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To illustrate the concept of Internet of Things (IoT).
2.	To familiarize with implementations of IoT for electrical engineering applications.

UNIT I	INTRODUCTION	9	0	0	9

Internet of Things - Definition- IoT conceptual framework-IoT architecture and Features, Major Components of IoT System, IoT software components for device hardware, Development Tools for IoT.

UNIT II	IOT DEVICES	9	0	0	9

Sensors: Sensing the Real World, Analog Sensors and Digital Sensors, Sensors for Temperature, Humidity, Distance, Light, Acceleration, Vibrations and Shocks, Orientation and Direction Compass, Magnetic Sensors/Magnetometer, Sound, Sensing the Things: Reading Barcodes, QR Code, Motion Sensors for Moving Objects, Environmental Monitoring Sensor, GPS, Actuator: Piezoelectric vibrators and sounders, Speakers, Solenoids, Servomotor, Relay switch.

UNIT III	IOT COMMUNICATION SYSTEM	9	0	0	9

M2M Communication for IoT, M2M Architecture, M2M Software and Development Tools, Modified OSI Model for the IoT/M2M Systems, Near-Field Communication, RFID, Bluetooth BR/EDR and Bluetooth Low Energy, ZigBee, Wi-Fi, GPRS/GSM Cellular Networks-Mobile Internet, Differences between NFC, BT LE, ZigBee and WLAN protocols.

UNIT IV	IOT DATA PROCESSING AND ANALYSIS	9	0	0	9

Data Acquiring and Storage: Data Generation, Data Acquisition, Data Validation, Data Categorization, Data Store, Data Centre Management, Server Management, Database Management System, Query Processing, SQL, NOSQL, Online Transactions and Processing, Business Intelligence, Complex Applications Integration, Online analytical processing, Analytics using Big Data in IoT/M2M, Knowledge-Management Reference Architecture.

UNIT V	IOT APPLICATIONS	9	0	0	9

Industrial IoT, Automotive IoT: Connected Cars Technology, Vehicle-to-Infrastructure Technology, Predictive and Preventive Maintenances, RFID IoT Systems: RFID IoT Network Architecture and Components of an RFID System, Wireless Sensor Network IoT Applications.

Total (45L+0T)= 45 Periods

Text Books:

1.	Pethuru Raj & Anupama C Mohan, The Internet of Things – Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017.

Reference Books:

1.	Raj Kamal, Internet of Things Architecture and Design Principles, McGraw Hill Education (India) Private Limited, 2017

E-Reference

1.	https://archive.nptel.ac.in/courses/106/105/106105166/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the structure and components of IOT system.	L1: Remembering
CO2	:	Select an appropriate device to interface IOT system with physical world	L4: Analyzing
CO3	:	Apply suitable communication technologies for IOT system	L3: Applying
CO4	:	Classify the data processing schemes for IoT application	L4: Analyzing
CO5	:	Use IOT platform for real time engineering solutions	L3: Applying

25PTEEPE36	MEMS AND NEMS			SEMESTER			VI
PREREQUISITES			CATEGORY	PE	Credit		3
NIL			Hours/Week	L	T	P	TH
				3	0	0	3

Course Objectives:

1.	To introduce the diverse technological and functional approaches of MEMS / NEMS and applications.
2.	To understand the microstructures and fabrication methods.
3.	To provide an insight of micro and nano sensors, actuators.
4.	To emphasise the need for NEMS technology.
5.	To update the ongoing trends and real time applications of MEMS and NEMS technology.

UNIT I	INTRODUCTION TO MEMS AND NEMS	9	0	0	9

Overview of Micro electro mechanical systems and Nano Electro mechanical systems, devices and technologies, Laws of scaling- Materials for MEMS and NEMS - Applications of MEMS and NEMS.

UNIT II	MICRO-MACHINING AND MICROFABRICATION TECHNIQUES	9	0	0	9

Photolithography- Micro manufacturing, Bulk micro machining, surface micro machining, LIGA.

UNIT III	MICRO SENSORS AND MICRO ACTUATORS	9	0	0	9

Micromachining: Capacitive Sensors- Piezoresistive Sensors- Piezoelectric actuators.

UNIT IV	NEMS TECHNOLOGY	9	0	0	9

Atomic scale precision engineering- Nano Fabrication techniques – NEMS for sensors and actuators

UNIT V	MEMS AND NEMS APPLICATION	9	0	0	9

Bio MEMS- Optical NEMS- Micro motors- Smart Sensors - Recent trends in MEMS and NEMS.

Total (45L+0T) = 45 Periods

Text Books:

1.	Chang Liu, "Foundations of MEMS", Pearson International Edition, 2011, 2nd Edition.
2.	Tai-.Ran Hsu, "MEMS and Microsystems: design , manufacture, and Nanoscale"- 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
3.	Lyshevski, S.E. "Nano- and Micro-Electromechanical Systems: Fundamentals of Nano-and Microengineering "2ndEdition, CRC Press, 2005.
4.	Julian W Gardner and Vijay K Varadan, "Microsensors, MEMS and Smart Devices", John Wiley and Sons Ltd, 2001, 1st Edition.

Reference Books:

1.	Marc F madou" Fundamentals of micro fabrication" CRC Press 2002 2nd Edition Marc Madou
2.	M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 16 Oct 2000, 1st Edition.
3.	Maluf, Nadim "An introduction to Micro Electro-mechanical Systems Engineering", AR Tech house, Boston, June 30 2004, 2nd Edition.
4.	Mohamed Gad – el – Hak, "MEMS Handbook" Edited CRC Press 2001, 1st Edition.

E-references:

1	https://www.academia.edu/Lectures_on_MEMS_and_MICROSYSTEMS_DESIGN_AND_MANUFACTURE

2	https://nptel.ac.in/courses
3.	https://www.iitk.ac.in/me/mems-fabrication
4	http://mems.iiti.ac.in/
5	https://onlinecourses.nptel.ac.in/noc22_ee36/preview

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the material properties and the significance of MEMS and NEMS for industrial automation.	L4: Analysing
CO2	:	Demonstrate knowledge delivery on micromachining and micro fabrication.	L2: Understanding
CO3	:	Apply the fabrication mechanism for MEMS sensor and actuators.	L3: Applying
CO4	:	Apply the concepts of MEMS and NEMS to models, simulate and process the sensors and actuators.	L3: Applying
CO5	:	Improve employability and entrepreneurship capacity due to knowledge up gradation on MEMS and NEMS technology.	L6: Creating

25PTEEPE41	POWER SYSTEM TRANSIENTS		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems; Power System Analysis and Stability		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on generation of switching transients and their control.
2.	To familiarise on the mechanism of lighting strokes and the production of lighting surges.
3.	To understand the propagation, reflection and refraction of travelling waves.
4.	To acquire knowledge on voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.

UNIT II	**SWITCHING TRANSIENTS**	**9**	**0**	**0**	**9**

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients - Ferro resonance.

UNIT III	**LIGHTNING TRANSIENTS**	**9**	**0**	**0**	**9**

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

UNIT IV	**TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS**	**9**	**0**	**0**	**9**

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.

UNIT V	**TRANSIENTS IN INTEGRATED POWER SYSTEM**	**9**	**0**	**0**	**9**

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

Total (45 L + 0 T) = 45 Periods

Text Books:

1.	Allan Greenwood, "Electrical Transients in Power Systems", Wiley Inter Science, New York, 2nd Edition, 1991.
2.	PritindraChowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.

3.	Indulkar, C.S., Kothari, D.P., and Ramalingam, K., "Power System Transients – A Statistical Approach", PHI Learning Private Limited, Second Edition, 2010.

Reference Books:

1.	Naidu, M.S., and Kamaraju, V., "High Voltage Engineering", McGraw Hill, Fifth Edition, 2013.
2.	Begamudre, R.D., "Extra High Voltage AC Transmission Engineering", Wiley Eastern Limited, 1986.
3.	Hase, Y., "Handbook of Power System Engineering", Wiley India, 2012.
4.	Kirtley, J.L., "Electric Power Principles, Sources, Conversion, Distribution and Use", Wiley, 2012.
5.	Akihiro Ametani, "Power System Transient theory and applications", CRC press, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Interpret the switching and lightning transients.	L4: Analysing
CO2	:	Examine the generation of switching transients and their control.	L4: Analysing
CO3	:	Analyse the mechanism of lightning strokes.	L4: Analysing
CO4	:	Recognize the importance of propagation, reflection, and refraction of travelling waves.	L1: Understanding
CO5	:	Review the concept of circuit breaker action, line dropping, and load rejection in an integrated power system.	L1: Understanding

25PTEEPE42	POWER QUALITY		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution system, Power System Protection and Switchgear		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the power quality terms and definitions
2.	To understand the sources and issues of various power quality problems.
3.	To gain in-depth knowledge of the mitigation/ suppression techniques of voltages sags, interruptions and harmonics.
4.	To introduce the computer tools for transient's analysis.
5.	To expose the various methods of power quality monitoring.

UNIT I	INTRODUCTION TO POWER QUALITY	9	0	0	9

Terms and definitions of Power quality, General classes of power quality problems: transients- long duration voltage variations- short duration voltage variations, voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations-International standard of power quality- Power Acceptability curves : CBEMA and ITI curves.

UNIT II	VOLTAGE SAGS AND LONG DURATION VOLTAGE VARIATIONS	9	0	0	9

Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of voltage sag Protection – voltage sag mitigation solution at the End-User level- Evaluating the economics of different ride-through alternatives –Motor Starting sags.

Long Duration voltage variations: Principles of regulating the voltage – devices for voltage regulation-utility voltage regulator application- capacitor for voltage regulation- End user capacitor application - Flicker: sources and mitigation techniques.

UNIT III	TRANSIENT OVERVOLTAGE	9	0	0	9

Sources of transient over voltage- Principles of overvoltage Protection- Devices for mitigation of over voltages – Utility capacitor-switching transients – Utility system lightning protection - Managing Ferro resonance- switching transients problems with loads - computer tools for transients analysis: PSCAD and EMTP.

UNIT IV	HARMONICS	9	0	0	9

Fundamentals of Harmonics: Harmonic Distortion, voltage versus current distortion, Harmonics versus transients- harmonics phase sequences- triplen harmonics -harmonic indices, harmonic sources from commercial and industrial loads. Locating harmonic sources - power system response characteristics – Effects of Harmonics Distortion –Interharmonics - harmonic distortion evaluations, Principles and devices for controlling harmonic distortion, IEEE and IEC standards on harmonics.

UNIT V	POWER QUALITY MONITORING	9	0	0	9

Monitoring considerations - power quality measurement equipment: disturbance analyser, spectrum and harmonics analysers, flicker meters, applications of Intelligent system for power quality monitoring

Total (45L+0T) = 45 Periods

Text Books:

1.	Roger. C. Dugan, Mark. F. McGranaghan, Surya Santoso, H.WayneBeaty, "Electrical Power Systems Quality", Tata McGraw Hill Publishing Company Ltd, New Delhi, Third Edition, 2012.
Reference Books	
1.	C. Sankaran ,"Power quality", CRC Press, First Indian Edition, 2009.
2.	G.T.Heydt, "Electric power quality", Stars in a Circle publishers, Second Edition, 2011.
3.	Arindam GhoshandGerald Ledwich, "Power Quality Enhancement Using Custom Power Devices", Springer-Verlag Publishers, New York Inc., Second Edition.2002.
E-Reference:	
1	www.onlinecourses.nptel.ac.in
2	www.class-central.com
3	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recite the definitions and characterization of various power quality issues.	L1: Remembering
CO2	:	Discuss the sources of sag & long duration voltage variations and its control methods	L2: Understanding
CO3	:	Summarize the sources of transient overvoltage and principle of control methods	L2: Understanding
CO4	:	Understand about harmonics problem and apply filters to suppress harmonics in distribution system	L3: Applying
CO5	:	Demonstrate the operation and application of power quality measuring equipment.	L3: Applying

25PTEEPE43	DISTRIBUTED GENERATION AND MICRO GRID		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution Systems,		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on distributed generation technologies.
2.	To familiarise on impact on grid integration.
3.	To understand the microgrid operation and control.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II	**DISTRIBUTED GENERATIONS**	**9**	**0**	**0**	**9**

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III	**IMPACT OF GRID INTEGRATION**	**9**	**0**	**0**	**9**

Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV	**BASICS OF A MICROGRID**	**9**	**0**	**0**	**9**

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

UNIT V	**CONTROL AND OPERATION OF MICROGRID**	**9**	**0**	**0**	**9**

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication-based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

Total (45 L + 0 T) = 45 Periods

Text Books:

1.	Lee Willis, H., Walter G. Scott , "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press, 2000.
2.	Godoy Simoes, M., Felix A. Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC Press, 2004.
3.	Robert Lasseter, and Paolo Piagi, "Micro-grid: A Conceptual Solution", PESC, June 2004.

Reference Books:

1.	John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, 2005.
2.	DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.

3.	AmirnaserYezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2009.
4.	Katiraei, F., and Iravani, M.R., “Transients of a Micro-Grid System with Multiple Distributed Energy Resources”, International Conference on Power Systems Transients (IPST’05) in Montreal, Canada on June 19-23, 2005.
5.	Ye, Z., Walling, R., Miller, N., Du, P., and Nelson, K., “Facility Microgrids”, General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Identify various forms of energy sources.	L2: Understanding
CO2	Recognize various DG technologies.	L2: Understanding
CO3	Analyse the impact on grid while integrating DGs.	L4: Analysing
CO4	Demonstrate the concepts of microgrids.	L3: Applying
CO5	Categorize various microgrid control schemes.	L4: Analysing

25PTEEPE44	RESTRUCTURED POWER SYSTEM			SEMESTER			VI
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System; Power System Analysis and Stability			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Objectives:							
1.	To impart knowledge on power system restructuring.						
2.	To familiarise on electricity market models.						
3.	To understand various network operations / analyses including transmission system operations, optimal power flow, and automatic generation control.						
UNIT I	**POWER SYSTEM RESTRUCTURING**			**9**	**0**	**0**	**9**
Introduction –Deregulation - Need for deregulation – Power system restructure models - Electricity Market Participants – GENCOS- DISCOS- TO- ISO- PX- SC - trading arrangements - Operational Planning Activities (OPA) of Electricity Market Participants - Causes of restructuring- types and effects of restructuring – restructure models							
UNIT II	**ELECTRICAL UTILITY**			**9**	**0**	**0**	**9**
Electrical utility restructuring Power System Operation in competitive environment –Electricity Market Models (PoolCo- bilateral- hybrid)- Components of restructured system - Power Sector restructuring and influence on environment - Functions and responsibilities of PX- ISO- RTO and ITP - Electric Utility Market – Market Models - wholesale electricity market characteristic – Electricity Market types (energy- ancillary services- transmission- forward- real time) – Market power evaluation and mitigation							
UNIT III	**EVALUATION OF TRANSMISSION SYSTEM**			**9**	**0**	**0**	**9**
Electricity pricing and Transmission pricing in a restructured market - Congestion management in a deregulated market – Available Transfer Capabilities (ATC) of transmission system – Application of Monte Carlo Simulation in ATC calculation – ATC calculation with sensitivity analysis method - Tagging Electricity Transaction – Tagging process – Implementation- Curtailment and cancellation of transaction - Availability Based Tariff							
UNIT IV	**OPTIMUM POWER FLOW (OPF) ANALYSIS IN MARKET ENVIRONMENT**			**9**	**0**	**0**	**9**
Introduction – Approaches to OPF – Application of OPF analysis in Electricity and Power Markets with Electricity Market Participants – Power Flow Tracing – current decomposition axioms- Mathematical model of loss allocation- usage sharing problem on transmission facilities - Methodology of graph theory - Economic issues- Mechanism and transmission issues in the new market environment.							
UNIT V	**AGC IN RESTRUCTURED POWER SYSTEM**			**9**	**0**	**0**	**9**
Introduction – Traditional Vs Restructured Scenario –AGC in New market environment - Block diagram and State Space representation of a two-area interconnected power system in deregulated environment – Load-Frequency Control (LFC) dynamics and Bilateral Contacts – Modelling- DISCO Participation Matrix (DPM)- Generation Participation Matrix (GPM).							
Total (45 L + 0 T) = 45 Periods							
Text Books:							
1.	Loi Lei Lai, "Power System Restructuring and deregulation"- John Wiley & Sons,2001.						

2.	Md. Shahidehpour, and MuwaffagAlmoush, "Restructured Electric Power System – Operation- Trading and Volatility", Marcel Dekker Inc, New York, 2001.
3.	Arthur. R. Bergen, and Vijay Vittal, "Power System Analysis," Prentice Hall, New Jersey, 2000.
Reference Books:	
1.	Xi Fan, Wang, Yonghua Song, and Malcolm Irving, "Modern Power System Analysis", Springer, 2008.
2.	Das, D., "Electrical Power Systems", New Age International (P) Ltd, New Delhi, 2008.
3.	Iiic, M., Galiana, F., and Fink, L., "Power Systems Restructuring" Norwell M A Kluwer, 1998.
4.	Philipson. L., and Willis H. Le, "Understanding Electric Utilities and de-regulation", Marcel Dekker Inc Publishers, New York, 2006.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize components in restructured power system.	L2: Understanding
CO2	:	Interpret various models in electricity market.	L3: Applying
CO3	:	Examine the congestion management and ATC in transmission system.	L4: Analysing
CO4	:	Formulate the power flow problem in restructured power system.	L4: Analysing
CO5	:	Develop automatic generation control in restructured power system.	L4: Analysing

<table>
<tr><td>25PTEEPE45</td><td colspan="3">CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES</td><td colspan="3">SEMESTER</td><td>VI</td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="7">To understand electric power Generation, Transmission and Distribution</td></tr>
<tr><td>2.</td><td colspan="7">To study Power System Operation and Control</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT I</td><td colspan="3">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT II</td><td colspan="3">CONVENTIONAL ENERGY CONVERSION TECHNOLOGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT III</td><td colspan="3">NON CONVENTIONAL ENERGY CONVERSION TECHNOLOGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT IV</td><td colspan="3">CONTROL ISSUES AND CHALLENGES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT V</td><td colspan="3">INTEGRATION OF ENERGY CONVERSION TECHNOLOGIES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations</td></tr>
<tr><td colspan="8">Total (45L+0T) = 45 Periods</td></tr>
<tr><td colspan="8">Text Books:</td></tr>
<tr><td>1.</td><td colspan="7">Renewable and Efficient Electric Power Systems, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013,2nd Edition</td></tr>
<tr><td>2.</td><td colspan="7">Microgrids and Active Distribution Networks, S.Chowdhury, S. P. Chowdhury, P.Crossley, IET Power Electronics Series, 2012.</td></tr>
<tr><td>3.</td><td colspan="7">Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali, Min Dai, John Wiley publishing company, 2010, 2nd Edition.</td></tr>
<tr><td colspan="8">Reference Books:</td></tr>
<tr><td>1.</td><td colspan="7">Solar Photovoltaic: Fundamentals, technologies & Applications, Chetan Singh Solanki, PHI Publishers, 2019, 3rd</td></tr>
</table>

	Edition.
2.	Solar PV Power: Design, Manufacturing and Applications from Sand to Systems, Rabindra Kumar Satpathy, Venkateswarlu Parmuru, Academic Press, 2020.
3.	Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013,1st Edition.
4.	Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, NavidZargari, IEEE- John Wiley and Sons Ltd. Publishers,2011,1st Edition.
5.	Report on "Large Scale Grid Integration of Renewable Energy Sources - Way Forward" Central Electricity Authority, GoI, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the importance of renewable energy sources.	L2: Understanding
CO2	:	Familiarize the conventional energy system.	L5: Evaluating
CO3	:	Familiarize the nonconventional energy system.	L3: Applying
CO4	:	Analyze and simulate control strategies for grid connected and off-grid systems.	L4: Analyzing
CO5	:	Develop converters to comply with grid standards to obtain grid integration.	L6: Creating

25PTEEPE46	DESIGN AND MODELLING OF RENEWABLE ENERGY SYSTEMS		SEMESTER			VI
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To review the renewable energy systems and technology
2.	To learn the Single-phase grid-connected photovoltaic systems and three phase photovoltaic systems
3.	To illustrate the small wind energy systems
4.	To simulate the Doubly-fed induction generator based WECS

UNIT I	**RENEWABLE ENERGY SYSTEMS: TECHNOLOGY OVERVIEW AND PERSPECTIVES**	**9**	**0**	**0**	**9**
Introduction-State of the Art- Examples of Recent Research and Development Challenges and Future Trends					
UNIT II	**SINGLE-PHASE GRID-CONNECTED PHOTOVOLTAIC SYSTEMS**	**9**	**0**	**0**	**9**
Introduction- Demands for Grid-Connected PV Systems-Power Converter Technology for Single- Phase PV Systems, Transformer less AC-Module Inverters (Module-Integrated PV Converters, Transformer less Single-Stage String Inverters, DC-Module Converters in Transformer less Double-Stage PV Systems					
UNIT III	**THREE-PHASE PHOTOVOLTAIC SYSTEMS: STRUCTURES, TOPOLOGIES**	**9**	**0**	**0**	**9**
Introduction-PV Inverter Structures, Three-Phase PV Inverter Topologies- -Control Building Blocks for PV Inverters, Modulation Strategies for Three-Phase PV Inverters, Implementation of the Modulation Strategies., Grid Synchronization, Implementation of the PLLs for Grid Synchronization, Current Control, Implementation of the Current Controllers, Maximum Power Point Tracking.					
UNIT IV	**SMALL WIND ENERGY SYSTEMS**	**9**	**0**	**0**	**9**
Introduction-Generator Selection for Small-Scale Wind Energy Systems- Turbine Selection for Wind Energy- Self-Excited Induction Generators for Small Wind Energy Applications- Permanent Magnet Synchronous Generators for Small Wind Power Applications- Grid-Tied Small Wind Turbine Systems-Magnus Turbine–Based Wind Energy System					
UNIT V	**DOUBLY-FED INDUCTION GENERATOR-BASED WECS**	**9**	**0**	**0**	**9**
Introduction – modelling of induction machine in machine variable form and arbitrary reference frame, modelling of Doubly-fed Induction Generator.					

Total (45L+0T)= 45 Periods

Text Books:

1.	Ahmad Azar, Nashwa Kamal, "Design, Analysis and Applications of Renewable Energy Systems", Academic Press, First Edition, 2021
2.	Ahmad Azar, Nashwa Kamal, "Renewable Energy Systems", Academic Press, First Edition, 2021
3.	Nabil Derbel, Quanmin Zhu, “Modeling, Identification and Control Methods in Renewable Energy Systems" , Springer, First Edition, 2019

Reference Books:	
1.	Power Conversion and Control of Wind Energy Systems, Bin Wu, 2011, Wiley-IEEE, 1st Edition.
2.	Wind Electrical Systems, S.N. Bhadra, 2005, Oxford, 7th Impression.
3.	Wind Power Integration - Connection and System Operational Aspects, Brendan Fox, 2014, IET, 2nd Edition.
4.	Renewable Energy Devices and Systems with Simulations in MATLAB and ANSYS, FredeBlaabjerg, Dan M. Ionel, CRC press, 2017, 1st Edition.
E-references	
1	https://www.mdpi.com/journal/applsci/topical_collections/Susta_Energy
2	https://www.mathworks.com/help/sps/ug/single-phase-grid-connected-in-pv-system.html
3.	https://www.sciencedirect.com/topics/engineering/three-phase-inverter
4	academia.edu/32704493/Wind_Power_Lecture_Notes
5	https://www.syscop.de/files/2018ss/WES/handouts/script.pdf
6	https://www.sciencedirect.com/topics/engineering/wound-rotor-induction-generator

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Overview of current trend in renewable energy systems.	L1: Remembering
CO2	:	Familiarize the integration of PV system with grid.	L3: Applying
CO3	:	Understand the different topologies of grid PV inverters.	L2: Understanding
CO4	:	Acquire knowledge on small wind energy system.	L2: Understanding
CO5	:	Understand the modelling of Doubly fed induction machine for RES.	L3: Applying

25PTEEPE51	UTILIZATION OF ELECTRICAL ENERGY			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines, Power System, Power Electronics			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Objectives:							
1.	To understand the economics of generation, tariff, and energy conservation methods.						
2.	To impart knowledge on principle and design of illumination systems.						
3.	To analyze the performance and different methods of electric heating and electric welding.						
4.	To impart knowledge on electric traction systems and their performance.						
5.	To understand electric drives for various industrial applications.						
UNIT I	**INTRODUCTION**			**9**	**0**	**0**	**9**
Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff – Availability Based Tariff (ABT) – Battery Energy Storage System (BESS) - Frequency Based energy measurement - Need for electrical energy conservation – methods- Introduction to Energy Audit							
UNIT II	**ILLUMINATION**			**9**	**0**	**0**	**9**
Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting							
UNIT III	**HEATING AND WELDING**			**9**	**0**	**0**	**9**
Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.							
UNIT IV	**ELECTRIC TRACTION**			**9**	**0**	**0**	**9**
Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.							
UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**			**9**	**0**	**0**	**9**
Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.							
Total (45L+0T)= 45 Periods							
Text Books:							
1.	C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Pvt.Ltd, 2003.						
2.	Eric Openshaw Taylor, "Utilisation of Electric Energy", English Universities Press Limited, 1937						
3.	J.B. Gupta, "Utilization of Electric Power and Electric Traction", S.K.Kataria and Sons, 2002.						
Reference Books:							
1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, "A Course in Utilization of Electrical Energy", Khanna Publishers, Delhi, 2003.						

2.	H. Partab, "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Co, New Delhi, 2004.
E-References:	
1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of generation, tariff, and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

25PTEEPE52	ELECTRICAL ENERGY CONSERVATION AND AUDITING		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Generation, Transmission and Distribution System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario of India.
2.	To familiarise the energy conservation methods.
3.	To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**

Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

UNIT II	**BASICS OF ENERGY**	**9**	**0**	**0**	**9**

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT III	**ENERGY MANAGEMENT AND AUDIT**	**9**	**0**	**0**	**9**

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

UNIT IV	**ENERGY EFFICIENCY**	**9**	**0**	**0**	**9**

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**	**9**	**0**	**0**	**9**

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45 L+ 0 T) = 45 Periods

Text Books:

1.	Sonal Desai, "Handbook of Energy Audit", McGraw Hill, 2015.
2,	Tripathy, S. C, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
3.	Hossam A Gabbar, "Energy Conservation in Infrastructure Systems", Wiley-IEEE Press, New Jersey, 2018

Reference Books:

1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2,	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	:	Recognize the various forms of energy.	L1: Understanding
CO3	:	Interpret energy management methods and energy auditing.	L3: Applying
CO4	:	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	:	Familiar with the advanced energy efficient technologies.	L4: Analysing

25PTEEPE53	ELECTRICAL WIRING, ESTIMATION AND COSTING			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Basic Electrical Engineering			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To describe the fundamental electrical tools required for electrical wiring and estimate the costing of electrical wiring for residential, industrial, overhead, underground and substations.

		L	T	P	TH
UNIT I	**ELECTRICAL WIRING & GENERAL PRINCIPLES OF ESTIMATION**	**9**	**0**	**0**	**9**

Guidelines for electrical wiring – Schematic diagram of electrical wiring system, sizes of wires, stranded wires, types of wires, wire splicing and termination, difference between neutral and earth wire, General idea about I.E rule - Indian Electricity Act.

General principles of estimation - Electrical Schedule of rates, catalogues, Survey and source selection, Recording of estimates Quantity and cost of material required. Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills

		L	T	P	TH
UNIT II	**RESIDENTIAL INSTALLATION**	**9**	**0**	**0**	**9**

Guidelines for electrical wiring installations of residential and positioning of equipment, Circuit design in lightning and power circuits , Method of drawing single line diagram, Selection of type of wiring and rating , Load calculations, Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for residential installations.

		L	T	P	TH
UNIT III	**COMMERCIAL INSTALLATION**	**9**	**0**	**0**	**9**

. Fundamental considerations for planning of electrical wiring installation for commercial buildings, Design considerations , Load calculations and selection of size of service connection, Deciding the size of cables, busbar and busbar chambers, Selection of rating of main switch, distribution board, Earthing, cable selection, ,Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for commercial installations.

		L	T	P	TH
UNIT IV	**OVERHEAD AND UNDERGROUND DISTRIBUTION SYSTEM**	**9**	**0**	**0**	**9**

Overhead distribution system and underground distribution system : materials and accessories required for the overhead distribution system, estimate for 440V/3-phase/ 4 wires or 3 wires overhead distribution system, types of service connections, method of installation of service connection(1-phase and 3-phase), I.E. rules pertaining to overhead lines and service connection.

		L	T	P	TH
UNIT V	**SUBSTATION**	**9**	**0**	**0**	**9**

Classification of substation, selection and location of site for substation, main electrical connections, graphical symbols for various types of apparatus and circuit elements on substation, main connection diagram, key diagram of typical sub stations, equipment for substation and switchgear installations, substation auxiliaries supply, substation earthing.

Total (45L+0T) = 45 Periods

Text Books:

1.	Raina K. B. and Bhattacharya S.K. " Electrical Design, estimating & Costing", New Age International (p) Limited, New Delhi,2007.
2.	Gupta J.B. , "Electrical Installation Estimating & Costing", S. K. Kataria& Sons, New Delhi,2015.
3.	Uppal S.L. "Electrical Estimating & Costing", New Age International (p) Limited, New Delhi ,2008
Reference Books:	
1.	SurjithSingh,"Electrical Estimating and Costing", Danpat Rai &Co.
2.	CEA Regulations 2010
3.	I.E rules for wiring and supply act manuals.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the guidelines for electrical wiring installations.	L1: Remembering
CO2	:	Apply appropriate select criteria and sizing of the electrical wiring for different systems.	L3: Applying
CO3	:	Analyse the load calculations and provide appropriate earthing provision.	L4: Analysing
CO4	:	Prepare a detailed estimate and costing.	L5: Evaluating
CO5	:	Differentiate the various electrical installation.	L2: Understanding

25PTEEPE54	**TRACTION ENGINEERING**			**SEMESTER**			**VII**
PREREQUISITES		**CATEGORY**		**PE**	**Credit**		**3**
Power Electronics, Electrical Machines		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To learn the fundamentals of electric traction, power substation, distribution system and overhead contact system design, construction and operation
2.	To learn the traction mechanics, power supply systems and role of battery banks and maintenance
3.	To learn the traction motor drives and control
4.	To learn about traction power supply and protection
5.	To learn about railway signalling

UNIT I	**INTRODUCTION TO ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

UNIT II	**TRACTION MECHANICS**	**9**	**0**	**0**	**9**

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

UNIT III	**TRACTION MOTOR AND DRIVES**	**9**	**0**	**0**	**9**

Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, speed control methods, Braking methods, special Emphasis and techniques of regenerative braking, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor/IGBT based Converter Controlled Drives, DC Traction using Chopper Controlled Drives, AC Traction employing Poly-phase motors, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & amp; Auxiliary circuit equipment (Other than traction motors), Linear Induction motors, introduction to Maglev Technology.

UNIT IV	**POWER SUPPLY AND PROTECTION**	**9**	**0**	**0**	**9**

Traction substation, spacing and location of Traction substations, Major equipment at traction substation, selection and sizing of major equipment like transformer and Switchgear, Types of protection provided for Transformer and overhead lines, surge protection, maximum demand and load sharing between substations, sectionalizing paralleling post and feeder posts, Booster transformers, Return Conductor, 2X25KV AC system, controlling/monitoring, Railway SCADA systems, Train lighting and Air-conditioning.
Design requirement of catenary wire, contact wire, Dropper, Height, span length, Automatic weight tensioning, section insulator, overlap, Different techniques of current collection (overhead and underground systems), neutral section, overhead crossing of power lines, Protection

UNIT V	RAILWAY SIGNALING	9	0	0	9
Block Section Concept, AC/DC Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing. Permissible limit of EMI and EMC, Permissible capacitively-coupled current, Coupling between circuits, conductive coupling, Electrostatic induction.					
Total (45L+0T) = 45 Periods					

Reference Books:

1.	E. A. Binney, "Electric Traction Engineering: An Introduction", Cleaver-Hume Press, 1955, 1 Oct 2007
2.	Douglas W. Hinde, M. Hinde, "Electric Traction Systems and Equipment", Elsevier Science & Technology, 1968
3.	Samuel Sheldon, Erich Hausmann, "Electric Traction and Transmission Engineering", Van Nostrand, 1911
4.	Frederick William Carter, "Railway Electric Traction", E. Arnold & Company, 1922
5.	Edward Parris Burch, "Electric traction for railway trains; a book for students, electrical and mechanical engineers, superintendents of motive power and others", New York, McGraw-Hill Book Company
6.	Edward Trevert, "Electric Railway Engineering", Lynn, Mass. :Bubier Pub. Co.
7.	Burch Edward Parris, "Electric Traction for Railway Trains; a Book for Students, Electrical and Mechanical Engineers, Superintendents of Motive Power and Others", Arkose Press, ISBN: 9781345582376, 9781345582376

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basics of traction and supply systems.	L2: Understanding
CO2	:	Understand the traction mechanics and ideal choice of supply systems.	L4: Analyzing
CO3	:	Describe the concepts of traction motors and applying the solid state drive control.	L3: Applying
CO4	:	Design the protection system for the traction power supply system	L5: Evaluating
CO5	:	Understand the concepts of railway signaling	L2: Understanding

25PTEEPE55	ENERGY STORAGE SYSTEMS AND APPLICATIONS		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Engineering		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the various types of energy storage technologies.
2.	To analyze thermal storage system.
3.	To analyze different battery storage technologies.
4.	To model the Lithium-ion batteries.
5.	To study the various applications of energy storage systems.

UNIT I	INTRODUCTION	9	0	0	9

Necessity of energy storage – Types of energy storage – Comparison of energy storage technologies – Demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

UNIT II	THERMAL STORAGE SYSTEM	9	0	0	9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modeling of phase change storage system – Simple units, packed bed storage units – Modeling using porous medium approach – Use of TRNSYS.

UNIT III	ELECTRICAL ENERGY STORAGE	9	0	0	9

Fundamental concept of batteries – Measuring battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries – Mathematical modeling of Lead Acid batteries – Flow batteries.

UNIT IV	LITHIUM-ION BATTERY MODELING	9	0	0	9

Analysis on charge and discharge temperature characteristics of Lithium-ion batteries – Electrothermal coupling Modeling - Modeling and Optimization of Air Cooling Heat Dissipation of Lithium-ion Battery Packs.

UNIT V	ALTERNATE ENERGY STORAGE TECHNOLOGIES	9	0	0	9

Flywheel, Supercapacitors, Principles and methods – Applications, Compressed air energy storage, Concept of Hybrid storage – Applications, Pumped hydro storage – Applications.

Total (45L+0T)= 45 Periods

Text Books:

1.	Ibrahim Dincer and Mark A. Rosen, ‘Thermal Energy Storage Systems and Applications’, John Wiley & Sons, 3rd Edition, 2021.
2.	Ru-shi Liu, Lei Zhang and Xueliang sun, ‘Electrochemical technologies for energy storage and conversion’, Wiley publications, 2nd Volume set, 2012.
3.	Junqiu Li, “Modeling and simulation of Lithium-ion power battery thermal management”, Springer, 2020.

Reference Books:

1.	Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1st Edition
2.	Schmidt. F.W. and Willmott. A.J., 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition
E-References:	
1.	Prof. SubhasishBasu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102
2.	Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course, https://nptel.ac.in/courses/112105221.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand different types of storage technologies.	L2: Understanding
CO2	:	Model a thermal battery energy storage system	L1: Remembering
CO3	:	Analyze the modeling of Lithium-ion batteries.	L4: Analyzing
CO4	:	Analyze the appropriate storage technologies for different applications.	L3: Applying
CO5	:	Explore the alternate energy storage technologies.	L2: Understanding

25PTEEPE56	SMPS AND UPS				SEMESTER		VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge about modern power electronic converters and their applications in power utility.
2.	To impart knowledge about Resonant converters and UPS.

UNIT I	**DC-DC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.

UNIT II	**SWITCHED MODE POWER CONVERTERS**	**9**	**0**	**0**	**9**

Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.

UNIT III	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**

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

UNIT IV	**DC-AC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.

UNIT V	**POWER CONDITIONERS, UPS, AND FILTERS**	**9**	**0**	**0**	**9**

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

Total (45L+0T)= 45 Periods

Text Books:

1.	Simon Ang, Alejandro Oliva," Power-Switching Converters", Third Edition, CRC Press, 2010.
2.	M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1.	Ned Mohan, Tore.M.Undeland, William.P.Robbins, "Power Electronics Converters, Applications and Design", 3rd Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, "Power Electronics circuits, devices and applications", 3rd Edition, PHI, New Delhi, 2007.

E-References:

1.	NPTEL Course: Power Electronics, IIT-B.
2.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding
CO5	:	Identify the filters and UPS.	L2: Understanding

25PTEEPE61	ENERGY MANAGEMENT SYSTEM AND SCADA		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power System		**Hours / Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To impart knowledge on energy management systems.
2. To understand network analysis function of EMS.
3. To study the function and control of SCADA.
4. To analyze the concept of SCADA hardware and software.
5. To study the concept of power system automation using SCADA.

UNIT I	ENERGY MANAGEMENT SYSTEM	9	0	0	9

Introduction to EMS, Objectives, Evolution of EMS, Evolution of SCADA, Function and Benefits of EMS, EMS Architecture, Practical EMS, Working of EMS, Power System Security: Introduction, Static Security Assessment, Operating states of Power System. Real Time or Online Application: Control Function, Protection Function, Operating States of Power System

UNIT II	NETWORK ANALYSIS FUNCTION OF EMS	9	0	0	9

Real Time Function, Extended Real Time Function, State Estimation: Introduction, Conventional State Estimation, Linea state estimation. Economic Dispatch and Optimal Power Flow: Introduction, Economic Dispatch, Generation Model Economic c Dispatch Problem, Optimal Power Flow problem Formulation.

UNIT III	SCADA	9	0	0	9

Introduction to SCADA, Evolution of SCADA, Benefits of SCADA, Function of SCADA, SCADA in Process control, SCADA Application, Usage of SCADA, Real-Time Monitoring and Control using SCADA, Data Acquisition, Data Communication, Data Presentation, and Control.

UNIT IV	SCADA HARDWARE AND SOFTWARE	9	0	0	9

Introduction, SCADA hardware Functions, Remote Terminal Units, SCADA RTU, Basic Functions, RTU Standards, Difference Between RTU and PLC, Features of SCADA. SCADA Software and Protocols: Introduction to ISO Model, DNP3 Model, Important Features of DNP3, IEC60870 PROTOCOL, HDLC, Modbus Protocol.

UNIT V	POWER SYSTEM AUTOMATION	9	0	0	9

Power System Automation – Benefits - Architecture for Power System Automation, Classification of Power system Automation, Implementation of Power System Automation and Protection using SCADA, SCADA based Model for Automation and Digital Protection.

Total (45L + 0T) = 45 Periods

Text Books:

1. Wayne C. Turner, Steve Doty, “Energy Management Hand book”, The Fairmont Press, 6^{th} Edition, 2007.
2. Handschin, E. “Energy Management Systems”, Springer Verlag, 1990.
3. Mini S. Thomas and John D McDonald, “Power System SCADA and Smart Grids”, CRC Press, 2015.

Reference Books:

1. John D Mc Donald, “Electric Power Substation Engineering”, CRC press, 2001

2.	E. Handschin, “Real Time Control of Electric Power Systems”, Elsevier, 1972.
E-Reference:	
1.	NPTEL Online Courses, Energy Management Systems and SCADA, IIT Madras. Link : “https://nptel.ac.in/courses/108106022/12“

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Explore the objectives of EMS.	L2: Understanding
CO2	:	Understand the real time function of EMS.	L1: Remembering
CO3	:	Explain the real time monitoring and control of SCADA.	L4: Analyzing
CO4	:	Analyze the hardware and software functions of SCADA.	L4: Analyzing
CO5	:	Outline the power system automation and protection using SCADA.	L2: Understanding

25PTEEPE62	INDUSTRIAL ELECTRICAL SYSTEMS		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Distribution System, Measurements and Instrumentation.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To emphasize the electrical components, safety equipment, residential and commercial installations, illumination systems and automation in Electrical Systems

UNIT I	ELECTRICAL SYSTEM COMPONENTS	9	0	0	9

LT system wiring components - Selection of cables, wires, switches, distribution box, metering system, Protection components- Fuse, MCB, MCCB, ELCB, RCCB – Construction and working of Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices, Single Line Diagram (SLD) of wiring system.

UNIT II	COMMERCIAL ELECTRICAL SYSTEMS	9	0	0	9

Types of commercial wiring systems, general rules and guidelines for installation, load calculations, selection and sizing of components, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, earthing of commercial installation.

UNIT III	ILLUMINATION SYSTEMS	9	0	0	9

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

UNIT IV	PROTECTION AND COMPENSATION MEASURES	9	0	0	9

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

UNIT V	ELECTRICAL SYSTEM AUTOMATION	9	0	0	9

Study of basic PLC, Role of PLC in automation, advantages of process automation, PLC based control system design, Panel Metering, Introduction to SCADA system for distribution automation.

Total (45L+0T) = 45 Periods

Text Books:

1.	S.L. Uppal and G.C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.
2.	K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
3.	S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
4.	H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

Reference Books:

1.	Partab, Art and Science of Utilization of Electrical Energy.
2.	Open Shaw Taylor, "Utilization of Electrical Energy", Oriented Longmans Limited, (Revised in SI Units), 1971.
3.	C. L Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Publishers, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Associate the various components of industrial electrical system	L2: Understanding
CO2	:	Apply appropriate criteria for selection and sizing of the different electrical systems.	L3: Applying
CO3	:	Recall the various terms and factors for illuminations systems	L1: Remembering
CO4	:	Analyse the essential safety, protection and compensation measures.	L4: Analysing
CO5	:	Select the appropriate electrical system for automation.	L4: Analysing

25PTEEPE63	ELECTRIC VEHICLES AND CONTROL		SEMESTER			VII
PREREQUISITES		CATEGORY	PE	Credit		3
Electrical drives and control		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

UNIT II	**PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**

Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages

UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Energy Management System (EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS

Total (45L+0T)= 45 Periods

Text Books:

1.	Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" CRC Press, 2016

Reference Books:

1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010

E-Reference	
1.	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding
CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

25PTEEPE64	EMBEDDED CONTROL FOR ELECTRICAL DRIVES		SEMESTER			VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide the control concept for electrical drives
2.	To emphasize the need of embedded systems for controlling the electrical drives
3.	To provide knowledge about various embedded system-based control strategies for electrical drives
4.	To Impart the knowledge of optimization and machine learning techniques used for electrical drives
5.	To familiarize the high-performance computing for electrical drives.

UNIT I	INTRODUCTION TO ELECTRIC DRIVES	9	0	0	9

Electric drives and its classification-Four-quadrant drive-Solid State Controlled Drives- Control techniques for electrical drives.

UNIT II	EMBEDDED SYSTEM FOR MOTOR CONTROL	9	0	0	9

Embedded Processors choice for motor control- Sensors and interface modules for Electric drives- Electrical drives applications.

UNIT III	INDUCTION MOTOR CONTROL	9	0	0	9

Speed control methods-PWM techniques- VSI fed three-phase induction motor- Embedded processor based three phase induction motor speed control.

UNIT IV	BLDC MOTOR CONTROL	9	0	0	9

Overview of BLDC Motor -Speed control methods -PWM techniques- Embedded processor based BDLC motor speed control.

UNIT V	SRM MOTOR CONTROL	9	0	0	9

Overview of SRM Motor -Speed control methods -PWM techniques- Embedded processor based SRM motor speed control.

Total (45L+0T)= 45 Periods

Text Books:

1.	R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”,Prentice-Hall of India Pvt. Ltd., New Delhi,2010, 1st Edition.
2.	Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization" Willey, 2007, 1st Edition

Reference Books:

1.	VedamSubramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw- Hill publishing company Ltd., New Delhi, 2002, 2nd Edition.
2.	K. Venkataratnam ,Special Electrical Machines, Universities Press, 2014, 1st Edition.
3.	Steve Furber, ‘ARM system on chip architecture’, Addision Wesley, 2nd Edition 2015

4.	Ron Sass and AnderewG.Schmidt, "Embedded System design with platform FPGAs: Principles and Practices", Elsevier, 2010, 1st Edition.
5.	Tim Wescott , Applied Control Theory for Embedded Systems , Elsevier, 2006, 1st Edition.
E-References:	
1.	https://archive.nptel.ac.in/courses/108/104/108104140/
2.	https://www.embedded.com/mcus-or-dsps-which-is-in-motor-control/
3.	https://www.e3sconferences.org/articles/e3sconf/pdf/2019/13/e3sconf_SeFet2019_01004.pdf
4.	https://www.electronics-tutorials.ws/blog/pulse-width-modulation.html
5.	http://kaliasgoldmedal.yolasite.com/resources/SEM/SRM.pdf

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Interpret the significance of embedded control for electrical drives	L2: Understanding
CO2	:	Deliver insight into various control strategies for electrical drives	L2: Understanding
CO3	:	Developing knowledge of control techniques for motor control.	L6: Creating
CO4	:	Develop embedded system solutions for drives used in Electric vehicles	L3: Applying
CO5	:	Knowledge up gradation on recent trends in embedded system skills required for motor control strategy	L6: Creating

25PTEEPE65	GRID INTEGRATION OF ELECTRIC VEHICLES			SEMESTER			VII
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**C**
				3	**0**	**0**	**3**

Course Objectives:

1. To know the basic details of V2G
2. To study the benefits & challenges of V2G
3. To learn EV & V2G on the smart grids renewable energy systems
4. To know the grid integration

UNIT I	DEFINITION, AND STATUS OF V2G	9	0	0	9

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

UNIT II	BENEFITS AND CHALLENGES OF V2G	9	0	0	9

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

UNIT III	CHALLENGES TO V2G	9	0	0	9

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

UNIT IV	IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS	9	0	0	9

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

UNIT V	GRID INTEGRATION AND MANAGEMENT OF EVS	9	0	0	9

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

Total (45L+0T)= 45 Periods

Reference Books:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, SumedhaRajakaruna ,FarhadShahnia and Arindam Ghosh,Springer, 2015, 1st Edition.
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor 1; Jesus Fraile-Ardanuy, IET 2020, 1st Edition.

4.	Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
5.	Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicleto-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the concepts related with V2G	L2: Understanding
CO2	:	Study the grid connection of 3 phase Q inverter	L3: Applying
CO3	:	Explain the technical, economics. business, regulatory & political challenges related with V2G	L2: Understanding
CO4	:	Demonstrate the impact of EV and V2G on smart grid and renewable energy system	L4: Analyzing
CO5	:	Explain the concept of grid integration and management of EVs.	L2: Understanding

25PTEEPE66	EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS			SEMESTER		VII
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Embedded System Design		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

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

UNIT I	INTRODUCTION TO AUTOMOTIVE SYSTEMS	9	0	0	9

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

UNIT II	SENSORS AND ACTUATORS FOR AUTOMOTIVES	9	0	0	9

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

UNIT III	VEHICLE MANAGEMENT SYSTEMS	9	0	0	9

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

UNIT IV	ONBOARD DIAGONSTICS AND COMMUNICATION	9	0	0	9

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

UNIT V	RECENT TRENDS	9	0	0	9

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

Total (45L+0T)= 45 Periods

Text Books:

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

Reference Books:

1.	Ali Emedi, Mehrdedehsani, John M Miller , "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 2004, 1st Edition.
2.	Jack Erjavec,JeffArias,"Alternate Fuel Technology-Electric ,Hybrid& Fuel Cell Vehicles",Cengage ,2012, 2nd Edition.

3.	Electronic Engine Control technology – Ronald K Jurgen Chilton's guide to Fuel Injection – Ford 2nd Edition, 2004.
4.	Automotive Electricals / Electronics System and Components, Tom Denton, 5th Edition, 2017.
5.	Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1st Edition, 2005.
6.	Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5th Edition, 2014.
7.	Automotive Hand Book, Robert Bosch, Bently Publishers, 10th Edition, 2018.
E-references:	
1	https://www.autosar.org/fileadmin/ABOUT/AUTOSAR_EXP_Introduction.pdf
2	https://microcontrollerslab.com/can-communication-protocol/
3.	https://ackodrive.com/car-guide/different-types-of-car-sensors/
4	https://www.tomtom.com/blog/automated-driving/what-is-adaptive-cruise-control/
5.	https://prodigytechno.com/difference-between-lin-can-and-flexray-protocols/
6.	https://www.synopsys.com/automotive/what-is-autonomous-car.html

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Insight into the significance of the role of embedded system for automotive applications.	L2: Understanding
CO2	:	Illustrate the need, selection of sensors and actuators and interfacing with ECU.	L2: Understanding
CO3	:	Develop the Embedded concepts for vehicle management and control systems.	L6: Creating
CO4	:	Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs.	L3: Applying
CO5	:	Improve employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.	L6: Creating