SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution | Approved by AICTE | Affiliated to Anna University | Accredited by NAAC with A++ Grade
Kuniamuthur, Coimbatore – 641008
Phone : (0422)-2678001 (7 Lines) | Email : info@skcet.ac.in | Website : www.skcet.ac.in

Curriculum & Syllabi

Regulation 2025

2025-2027 Batch

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.E., Power Systems Engineering

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(Batch 2025-2027)

VISION OF THE INSTITUTION

- To Produce Globally Competitive Engineers with High Ethical Values and Social Responsibilities.

MISSION OF THE INSTITUTION

- To impart the highest quality state-of-the-art technical education by providing impetus to innovation, research, and development and empowering students with entrepreneurship skills.
- To instill ethical values, imbibe a sense of social responsibility, and strive for societal well-being.
- To identify the needs of society and offer sustainable solutions through outreach programs.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

- To provide the students with high quality technical education in the field of Electrical and Electronics Engineering enabling them to become competent and responsible engineers with employability and entrepreneurial skills.

MISSION OF THE DEPARTMENT

- To equip the students with adequate knowledge in the field of Electrical and Electronics Engineering and professional skills necessary to face the future challenges with confidence and courage.
- To enrich them to engage in research activities leading to innovative applications of technology.
- To enable them to become responsible citizens of the country with a willingness to serve the society.

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1	Exhibit technical competence in Electronics and Communication Engineering by providing innovative engineering solutions and excel in professional career.
PEO 2	Indulge in problem identification, analysis and formulation to provide technically superior, economically feasible, environmentally compatible and socially acceptable design solutions.
PEO 3	Contribute towards entrepreneurship and research, and exercise leadership through effective communication, teamwork and knowledge upgradation through lifelong learning.

II. PROGRAMME OUTCOMES (POs)

PO 1	**Engineering Knowledge:** Apply the knowledge of basic sciences and engineering fundamentals to solve engineering problems.
PO 2	**Problem Analysis:** Analyze the complex engineering problems and give solutions related to chemical & allied industries
PO 3	**Design/ Development of Solutions:** Identify the chemical engineering problems, design and formulate solutions to solve both industrial & social related problems.
PO 4	**Conduct Investigations of Complex Problems:** Design & conduct experiments, analyze and interpret the resulting data to solve Chemical Engineering problems.
PO 5	**Modern Tool Usage:** Apply appropriate techniques, resources and modern engineering & IT tools for the design, modelling, simulation and analysis studies.
PO 6	**The Engineer and Society:** Assess societal, health, safety, legal and cultural issues and their consequent responsibilities relevant to professional engineering practice.
PO 7	**Environment and Sustainability:** Understand the relationship between society, environment and work towards sustainable development.
PO 8	**Ethics:** Understand their professional and ethical responsibility and enhance their commitment towards best engineering practices.
PO 9	**Individual and Team Work:** Function effectively as a member or a leader in diverse teams, and be competent to carry out multidisciplinary tasks.
PO 10	**Communication:** Communicate effectively in both verbal & non-verbal and able to comprehend & write effective reports.
PO 11	**Project Management and Finance:** Understand the engineering and management principles to manage the multidisciplinary projects in whatsoever position they are employed.
PO 12	**Life-Long Learning:** Recognize the need of self-education and life-long learning process in order to keep abreast with the ongoing developments in the field of engineering

III. PROGRAMME SPECIFIC OUTCOMES (PSOs)	
The Graduates of B.E – ELECTRICAL AND ELECTRONICS ENGINEERING programme will be able to:	
PSO 1	Analyze basic scientific concepts and provide solutions to Electrical and Electronics Engineering problems with a specific focus on emerging energy challenges.
PSO 2	Use relevant software, apply current techniques for data processing problems in the field of modern electronic systems for sustainable development.
PSO 3	Develop products/software to cater to the societal & Industrial needs and adapt ethical values so as to become successful electrical engineering professionals.

II. IV. MAPPING OF PEOs WITH POs

PEO	**Pos**										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
1	3	3	3	2	3	2	2	3	3	3	2
2	3	3	3	3	3	2	2	2	2	2	3
3	2	2	2	2	2	2	2	3	3	3	2
4	3	3	3	2	2	3	3	3	2	2	2
5	3	3	2	3	3	2	2	2	2	2	3
	1- low, 2 - medium, 3 - high, ‘-' - no correlation										

V. MAPPING OF PEOs WITH PSOs

	PSO 1	**PSO 2**	**PSO 3**
PEO 1	3	2	3
PEO 2	3	3	2
PEO 3	2	3	3
PEO 4	3	2	3
PEO 5	2	3	2
PEO 1	3	2	3

AUTONOMOUS CURRICULA AND SYLLABI

Regulations 2025

SEMESTER I							
S.No	**Course Code**	**Course**	**L/T/P**	**Contact hrs/ Wk**	**Credits**	**Ext/Int**	**Cat.**
THEORY							
1	25PMA104	Mathematical Methods for Power Engineering	3/0/0	3	3	60/40	FC
2	25PPS101	Advanced Power System Analysis	3/0/0	3	3	60/40	PCC
3	25PPS102	Restructured Power System	3/0/0	3	3	60/40	PCC
4	25PPSXXX	Professional Elective - I	3/0/0	3	3	60/40	PEC
5	25PPSXXX	Professional Elective - II	3/0/0	3	3	60/40	PEC
PRACTICAL							
6	25PPS103	Power System Steady State Analysis Laboratory	0/0/4	4	2	40/60	PCC
EMPLOYABILITY ENHANCEMENT COURSES							
7	25PTS101	Technical Seminar-I	0/0/3	3	1.5	0/100	EEC
AUDIT COURSE							
8	25PADXXX	Audit Course - I	2/0/0	2	-	-	AC
		Total	**17/0/8**	**25**	**20.5**	**800**	

SEMESTER II							
S.No	**Course Code**	**Course**	**L/T/P**	**Contact hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
THEORY							
1	25PPS201	Digital Protection of Power System	3/0/0	3	3	60/40	PCC
2	25PPS202	Power System Dynamics and Stability	3/0/0	3	3	60/40	PCC
3	25PPSEXX	Professional Elective – III	3/0/0	3	3	60/40	PEC
4	25PPSEXX	Professional Elective - IV	3/0/0	3	3	60/40	PEC
5	25PPSEXX	Professional Elective – V	3/0/0	3	3	60/40	PEC
PRACTICAL							
6	25PPS203	Power Systems Simulation Laboratory	0/0/4	4	2	40/60	PCC
7	25PPS204	Power System Dynamics Laboratory	0/0/4	4	2	40/60	PCC

EMPLOYABILITY ENHANCEMENT COURSE							
8	25PTS201	Technical Seminar-II	0/0/3	3	1.5	0/100	EEC
AUDIT COURSE							
9	25PADXXX	Audit Course - II	2/0/0	2	-	-	AC
		Total	**17/0/8**	**25**	**18.5**	**700**	

SEMESTER III

S. No.	Course Code	Course	L/T/P	Contact hrs/Wk	Credits	Ext/Int	Cat.
THEORY							
1	25PPSEXX	Professional Elective – VI	3/0/0	3	3	60/40	PEC
2	25PPSEXX	Professional Elective – VII	3/0/0	3	3	60/40	PEC
3	25PXXOXX	Open Elective	3/0/0	3	3	60/40	OE
EMPLOYABILITY ENHANCEMENT COURSE							
4	25PPSP01	Project Work Phase-I	0/0/12	12	6	60/40	EEC
MANDATORY COURSE							
5	25PMC001	Research Methodology and IPR	2/0/0	2	-	-	MC
		Total	**11/0/12**	**23**	**15**	**400**	

SEMESTER IV

S. No.	Course Code	Course	L/T/P	Contact hrs/ Wk	Credits	Ext/Int	Cat.
EMPLOYABILITY ENHANCEMENT COURSE							
1	25PPSP02	Project Work Phase-II	0/0/32	32	16	60/40	EEC
		Total	**0/0/32**	**32**	**16**	**100**	

CURRICULUM STRUCTURE FOR M.E. DEGREE PROGRAMME

S.No	Course Work - Subject Area	AICTE Credits	SKCT Credits
1.	Foundation courses (FC) including Mathematics or other basic courses	-	03
2.	Professional Core Courses (PCC), relevant to the chosen specialization/branch	20	18
3.	Professional Elective Courses (PEC) relevant to the chosen specialization/ branch.	15	21
4.	Open Elective Courses (OE) are of importance in the context of special skill development offered by other than the parent department	03	03
5.	Employability Enhancement Courses (EEC) –Project work, Seminar, Internship, Professional Practices, Case study and Industrial / Practical Training.	28	25
6.	Audit Courses (AC)	-	-
7.	Mandatory Courses (MC)	02	-
	Total	68	70

SCHEME OF CREDIT DISTRIBUTION – SUMMARY

S. No.	Stream	Credits/Semester				Credits	%
		I	II	III	IV		
1.	Foundation Courses (FC)	03	-	-	-	**03**	**4.29**
2.	Professional Core Courses (PCC)	10	08	-	-	**18**	**25.71**
3.	Professional Elective Courses (PEC)	06	09	06	-	**21**	**30**
4.	Open Elective Courses (OE)	-	-	03	-	**03**	**4.29**
5.	Employability Enhancement Courses (EEC)	1.5	1.5	06	16	**25**	**35.71**
6.	Audit Courses (AC)	-	-	-	-	**-**	**-**
7.	Mandatory Courses (MC)	-	-	-	-	**-**	**-**
	Total	**20.5**	**18.5**	**15**	**16**	**70**	**100.00**

SCHEME OF COURSE DISTRIBUTION – SUMMARY

S. No.	Stream	Course/Semester				Total	%
		I	II	III	IV		
1.	Foundation Courses (FC)	01	-	-	-	**01**	**4.35**
2.	Professional Core Courses (PCC)	04	03	-	-	**07**	**30.43**
3.	Professional Elective Courses (PEC)	02	03	02	-	**07**	**30.43**
4.	Open Elective Courses (OE)	-	-	01	-	**01**	**4.35**
5.	Employability Enhancement Courses (EEC)	01	01	01	01	**04**	**17.39**
6.	Audit Courses (AC)	01	01	-	-	**02**	**8.70**
7.	Mandatory Courses (MC)	-	-	01	-	**01**	**4.35**
	Total	**09**	**08**	**05**	**01**	**23**	**100**

FOUNDATION COURSES (03 credits)

S.No.	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Cat.
1.	23PMA104	Mathematical Methods for Power Engineering	3/0/0	3	3	FC

PROFESSIONAL CORE COURSES (18 credits)

S.No.	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Cat.
1.	25PPS101	Advanced Power System Analysis	3/0/0	3	3	PCC
2.	25PPS102	Power System Dynamics-I	3/0/0	3	3	PCC
3.	25PPS103	Power System Steady State Analysis Laboratory	0/0/4	4	2	PCC
4.	25PPS104	Power System Dynamics Laboratory	0/0/4	4	2	PCC
5.	25PPS201	Digital Protection of Power System	3/0/0	3	3	PCC
6.	25PPS202	Power System Dynamics-II	3/0/0	3	3	PCC
7.	25PPS203	Power Systems Simulation Laboratory	0/0/4	4	2	PCC

PROFESSIONAL ELECTIVE COURSES (21 Credits)

S. No.	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Cat.
1.	25PPSE01	Modern Power Generation	3/0/0	3	3	PEC
2.	25PPSE02	Smart grid	3/0/0	3	3	PEC
3.	25PPSE03	Transducers and Smart Instruments	3/0/0	3	3	PEC
4.	25PPSE04	Solar and Energy Storage Systems	3/0/0	3	3	PEC

5.	25PPSE05	Electrical Power Distribution System	3/0/0	3	3	PEC
6.	25PPSE06	Pulse Width Modulation for PE Converters	3/0/0	3	3	PEC
7.	25PPSE07	Electric and Hybrid Vehicles	3/0/0	3	3	PEC
8.	25PPSE08	Power Electronics for Renewable Energy	3/0/0	3	3	PEC
9.	25PPSE09	Power Quality	3/0/0	3	3	PEC
10.	25PPSE10	Dynamics of Electrical Machines	3/0/0	3	3	PEC
11.	25PPSE11	Optimal Control Theory	3/0/0	3	3	PEC
12.	25PPSE12	Renewable Energy System	3/0/0	3	3	PEC
13.	25PPSE13	Advanced Digital Image Processing	3/0/0	3	3	PEC
14.	25PPSE14	Nanotechnology For Energy Systems	3/0/0	3	3	PEC
15.	25PPSE15	High Power Converters	3/0/0	3	3	PEC
16.	25PPSE16	Artificial Intelligent Techniques	3/0/0	3	3	PEC
17.	25PPSE17	Micro Electro Mechanical System	3/0/0	3	3	PEC
18.	25PPSE18	Nano Electronics and Nano Photonics	3/0/0	3	3	PEC
19.	25PPSE19	SCADA System and Applications	3/0/0	3	3	PEC
20.	25PPSE20	Power System Transients	3/0/0	3	3	PEC
21.	25PPSE21	FACTS and Custom Power Devices	3/0/0	3	3	PEC
22.	25PPSE22	Power System Planning and Reliability	3/0/0	3	3	PEC
23.	25PPSE23	Advanced Electric Drives and Controls	3/0/0	3	3	PEC

OPEN ELECTIVE COURSES (3 credits)

S. No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Cat.
1.	25PCSO01	Business Analytics	3/0/0	3	3	OEC
2.	25PEDO01	Industrial Safety	3/0/0	3	3	OEC
3.	25PEDO02	Operations Research	3/0/0	3	3	OEC
4.	25PEDO03	Cost Management of Engineering Projects	3/0/0	3	3	OEC
5.	25PSEO01	Composite Materials	3/0/0	3	3	OEC
6.	25PPSO01	Waste to Energy	3/0/0	3	3	OEC

EMPLOYABILITY ENHANCEMENT COURSES (25Credits)

S. No.	Course Code	Course Title	L/T/P	Contact Hrs/ Wk	Credits	Cat.
1	25PTS101	Technical Seminar-I	0/0/3	3	1.5	EEC
2	25PTS201	Technical Seminar-II	0/0/3	3	1.5	EEC
3	25PPSP01	Project Work Phase-I	0/0/12	12	6	EEC
4	25PPSP02	Project Work Phase-II	0/0/32	32	16	EEC

AUDIT COURSES (AC)

S. No.	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Cat.
1	25PAD001	English for Research Paper Writing	2/0/0	2	-	AC
2	25PAD002	Disaster Management	2/0/0	2	-	AC
3	25PAD003	Value Education	2/0/0	2	-	AC
4	25PAD004	Constitution of India	2/0/0	2	-	AC
5	25PAD005	Pedagogy Studies	2/0/0	2	-	AC
6	25PAD006	Stress Management by Yoga	2/0/0	2	-	AC
7	25PAD007	Personality Development through Life Enlightenment Skills	2/0/0	2	-	AC

MANDATORY COURSE

S. No.	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Cat.
1	25PMC001	Research Methodology and IPR	2/0/0	2	-	MC

25PMA104	MATHEMATICAL METHODS FOR POWER ENGINEERING	3/0/0/3
Nature of the Course	: Theory	
Pre requisite(s)	**:** Nil	

Course Objectives:

To understand the relevance of mathematical methods to solve engineering problems and to understand how to apply these methods for a given engineering problem.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand about vector spaces, linear transformation, eigen values and eigenvectors of linear operators	U
CO2	Apply simplex methods for solving linear programming problems in various fields of science and technology	AP
CO3	Apply various techniques used for solving constrained and unconstrained nonlinear programming problems	AP
CO4	Analyze the concept of random variables, functions of random variable and their probability distribution	AN
CO5	Understand stochastic processes and their classification	U

Course Contents:

MODULE-1 **15 Hours**
Vector spaces, Linear transformations, Matrix representation of linear transformation. Eigen values and Eigen vectors of linear operator

MODULE-2 **15 Hours**
Linear Programming Problems, Simplex Method, Duality, Non Linear Programming problems. Unconstrained Problems, Search methods, Constrained Problems

MODULE-3 **15 Hours**
Lagrange method, Kuhn-Tucker conditions, Random Variables, Distributions. Independent Random Variables, Marginal and Conditional distributions, Elements of stochastic processes

Total Hours: 45

Text Books:

1. Kenneth Hoffman and Ray Kunze, “Linear Algebra”, 2nd Edition, PHI,1992
2. Erwin Kreyszig, “Introductory Functional Analysis with Applications”, John Wiley & Sons, 2004
3. Irwin Miller and Marylees Miller, John E. Freund’s “Mathematical Statistics”, 6th Edn, PHI,2002

Reference Books:

1. A Papoulis, “Probability, Random Variables and Stochastic Processes”, 3rd Edition, Mc Graw Hill,2002
2. John B Thomas, “An Introduction to Applied Probability and Random Processes”, John Wiley,2000
3. Hillier F S and Liebermann G J, “Introduction to Operations Research”, 7th Edition, McGraw Hill,2001

Web References:

1	https://nptel.ac.in/courses/108108109/
2	https://nptel.ac.in/syllabus/111105035/

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	2					3
CO2	2					3
CO3	2					2
CO4	2					2
CO5	2					2

25PPS101	ADVANCED POWER SYSTEM ANALYSIS	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	: Power system Analysis	

Course Objectives:

1. To explore on the application of mathematical techniques in power system.
2. To provide depth knowledge about the concepts of power system load flow analysis, fault analysis and stability analysis with its solution techniques.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand the operation of the power system in terms of frequency regulation, economic dispatch and unit commitment.	[UN]
2	Analyse load flow concepts and to study system performance under different operating conditions with its solution techniques	[AN]
3	Examine the concepts of optimal power flow with its problem statement and solution techniques	[AN]
4	Analyse the fault using symmetrical components and determine fault currents and voltages at various locations in the network.	[AN]
5	Understand the principles of steady-state stability assessment and transient stability assessment in power systems.	[UN]

Course Contents:

Module 1: Solution Technique **9 Hours**

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

Module 2: Power Flow Analysis **18 Hours**

Power flow equation in real and polar forms; Review of Newton's method for solution; Adjustment of P-V buses; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method. Optimal Power Flow :Problem statement; Solution of Optimal Power Flow (OPF) – The gradient method, Newton's method, Linear Sensitivity Analysis; LP methods – With real power variables only – LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

Module 3: Short Circuit Analysis **18 Hours**

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. Transient Stability Analysis: Introduction, Numerical Integration Methods: Euler and Fourth Order Runge- Kutta methods, Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model; Factors influencing transient stability, Numerical stability and implicit Integration methods.

Total Hours:	**45**

Text Books:	
1. G W Stagg, A.H El. Abiad "Computer Methods in Power System Analysis", McGraw Hill, 2017 2. P.Kundur, "Power System Stability and Control", McGraw Hill,1994	
Reference Books:	
3. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", John Wiley and sons, New York,1996. 4. W.F.Tinney and W.S.Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug1973. 5. K. Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96; Book on "Large Sparse Set of Linear Systems" Editor: J.K. Rerd, Academic Press, 1971.	
Web References:	
1	https://nptel.ac.in/courses/108105067
2	https://freevideolectures.com/course/2353/power-systems-analysis
Online Resources:	
1	https://www.coursera.org/learn/electric-power-systems
2	https://www.coursera.org/specializations/energy-industry
3	https://www.coursera.org/learn/current-control
4	https://www.coursera.org/learn/electricity

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	**3**	**2**	**2**	**3**	**3**	**2**
CO2	**3**	**2**	**2**	**3**	**3**	**2**
CO3	**3**	**2**	**2**	**3**	**3**	**2**
CO4	**3**	**2**	**2**	**3**	**3**	**2**
CO5	**3**	**2**	**2**	**3**	**3**	**2**

25PPS102	RESTRUCTURED POWER SYSTEMS	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	-	

Course Objectives:

1. To impart knowledge on the need for restructuring the power sector
2. To learn about the challenges involved in the functions of restructured power market
3. To have an exposure on economics involved in power market

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand different restructuring models and key issues in electric utilities restructuring	U
CO 2	Illustrate the concepts of generation, power exchange, scheduling, different types of market operations for California Markets and New York Markets and also about transmission management and congestion management	U
CO3	Understand OASIS structure, functionality and architecture, transfer capability issues and transmission services.	U
CO 4	Understand the essence of electric energy trading. Understand volatility and risk.	U
CO 5	Understand the forecasting in electricity pricing.	U

Course Contents:

MODULE 1: Overview of Key Issues in Electric Utilities Restructuring 15 Hours
Restructuring Models: Pool Co Model, Bilateral Contracts Model, Hybrid Model - Independent System Operator (ISO): The Role of ISO - Power Exchange(PX): Market Clearing Price(MCP) – Market operations: Day- ahead and Hour-Ahead Markets, Elastic and Inelastic Markets - Market Power – Stranded costs - Transmission Pricing: Contract Path Method, The MW-Mile Method - Congestion Pricing: Congestion Pricing Methods, Transmission Rights - Management of Inter-Zonal/Intra Zonal Congestion: Solution procedure, Formulation of Inter-Zonal Congestion Sub problem, Formulation of Intra-Zonal Congestion Sub problem.

MODULE 2: Electric Utility Markets in the United States 15 Hours
California Markets: ISO, Generation, Power Exchange, Scheduling Co-ordinator, UDCs, Retailers and Customers, Day-ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts(TCCs) - New York Market: Market operations - PJM interconnection - ERCOT ISO - New England ISO - Midwest ISO - Maintenance Schedule Coordination - Summary of functions of U.S. ISOs. Open Access Same-Time Information System :FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Implementation of OASIS Phases: Phase 1, Phase 1-A, Phase 2 - Posting of information: Types of information available on OASIS, Information requirement of OASIS, Users of OASIS - Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation - Transmission Services - Methodologies to Calculate ATC - Experiences with OASIS in some Restructuring Models: PJM OASIS, ERCOT OASIS.

MODULE 3: Electric Energy Trading and Pricing 15 Hours
Essence of Electric Energy Trading - Energy Trading Framework: The Qualifying factors -

Derivative Instruments of Energy Trading: Forward Contracts, Futures Contracts, Options, Swaps, Applications of Derivatives in Electric Energy Trading – Port Folio Management: Effect of Positions on Risk Management - Energy Trading Hubs - Brokers in Electricity Trading - Green Power Trading. Electricity Pricing - Volatility, Risk and Forecasting: Electricity Price Volatility: Factors in Volatility, Measuring Volatility - Electricity Price Indexes: Case Study for Volatility of Prices in California, Basis Risk - Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves - Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves – Short- term Price Forecasting: Factors Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors, Practical Data Study.

Total Hours: 45

Text Books:

1. W.F. Tinney and W.S. Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug1973.
2. P. Kundur, "Power System Stability and Control", McGraw Hill,1994.

Reference Books:

1. G W Stagg, A.H El. Abiad "Computer Methods in Power System Analysis", Mc Graw Hill, 1968.
2. A.J. Wood and B.F. Wollenberg, "Power Generation Operation and Control", John Wiley and sons, New York,1996.
3. K. Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques ; pp:75-96 ; Book on "Large Sparse Set of Linear Systems" Editor: J.K.Rerd, Academic Press, 1971.

Web References:

1	https://nptel.ac.in/courses/108101005

Online Resources:

1	https://www.coursera.org/learn/electric-power-systems
2	https://www.coursera.org/specializations/energy-industry
3	https://www.coursera.org/learn/current-control

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPS103	POWER SYSTEM STEADY STATE ANALYSIS LABORATORY	0/0/4/2

Nature of the Course	: Practical
Pre-request	: Power system Analysis

Course Objectives:

1. To provide experimental knowledge on power system network at normal condition and fault condition.
2. To have an exposure on simulations software tools.

Course Outcomes:
Upon completion of the course, students shall have the ability to

CO1	Determine the parameters of the given power system network	[AP]
CO2	Apply load flow solution methods to determine voltage magnitude, angle at various buses, real and reactive power flow at lines, transmission losses	[AP]
CO3	Analyze the load frequency dynamics of single and two area power system	[AN]
CO4	Compute the fault current under various fault conditions	[AP]
CO5	Analyze the performance of thyristor converters and IGBT inverters	[AN]
CO6	Analyze load forecasting and unit commitment solution methods	[AN]

Course Contents:

S.No.,	List of Experiments	CO Mapping	RBT
1.	Computation of Parameters and Modelling of Transmission Lines	CO1	AP
2.	Solution of Power Flow Using Gauss-Seidel Method	CO2	AN
3.	Solution of Power Flow Using Newton Raphson Method	CO2	AN
4.	Load – Frequency Dynamics of Single Area Power Systems	CO3	AN
5.	Load – Frequency Dynamics of Two Area Power Systems	CO3	AN
6.	Simulation of single phase and three phase IGBT Inverters.	CO5	AN
7.	Simulation of Thyristor Converters.	CO5	AN
8.	Study of Transient Stability.	CO4	U
9.	Short Circuit Studies	CO4	AN
10.	Load Forecasting and Unit Commitment	CO6	AP

Total Hours:	**60**

Text Books:

1. G W Stagg, A.H El. Abiad “Computer Methods in Power System Analysis”, McGraw Hill, 2017
2. P.Kundur, “Power System Stability and Control”, McGraw Hill,1994

Reference Books:

1. A.J.Wood and B.F.Wollenberg, “Power Generation Operation and Control”, John Wiley and sons, New York,1996.
2. W.F.Tinney and W.S.Meyer, “Solution of Large Sparse System by Ordered Triangular Factorization” IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug1973.
3. K.Zollenkopf, “Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96; Book on “Large Sparse Set of Linear Systems” Editor: J.K. Rerd, Academic Press, 1971.

Web References:

1	https://www.youtube.com/watch?v=msV3XXemCHQ
2	https://www.youtube.com/watch?v=Knpt6zcK_CU
3	https://nptel.ac.in/courses/108105067
4	https://freevideolectures.com/course/2353/power-systems-analysis

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3		3	3	3	2
CO2	3	2	3	3	3	2
CO3	3		3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2
CO6	3	2	3	3	3	2

25PPS201	DIGITAL PROTECTION OF POWER SYSTEM	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To impart knowledge on digital power system protection.
2. To learn about microprocessor based relays and protective schemes for transmission lines and power apparatus
3. To augment the knowledge on modern day's protection

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Illustrate the concept and working of different types of digital relays	**U**
CO2	Analyze various type of digital protection schemes for transmission lines.	**AN**
CO3	Analyze various type of digital protection schemes for synchronous generator and transformers.	**AN**
CO4	Illustrate the relay settings and relay coordination	**AP**
CO5	Articulate the applications of computers in short circuit studies	**AP**

Course Contents:

MODULE 1 Numerical Protection and Digital Protection of Transmission Line 15 Hours
Introduction, block diagram of numerical relay, sampling theorem, correlation with a reference wave, Least Error Squared (LES) technique, digital filtering, numerical overcurrent protection.
Digital Protection of Transmission Line :Introduction, Protection scheme of transmission line, distance relays, traveling wave relays, digital protection scheme based upon fundamental signal, hardware design, software design, digital protection of EHV/UHV transmission line based upon traveling wave phenomenon, new relaying scheme using amplitude comparison.

MODULE 2 Digital Protection of Synchronous Generator and Power Transformer 15 Hours
Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator. Faults in a transformer, schemes used for transformer protection, digital protection of transformer.

MODULE 3 Relay setting and PC Applications in Short Circuit Studies for Designing Relaying Scheme 15 Hours
Distance and Overcurrent Relay Setting and Co-Ordination: Directional instantaneous IDMT overcurrent relay, directional multizone distance relay, distance relay setting, co-ordination of distance relays, co-ordination of overcurrent relays, computer graphics display, man-machine interface subsystem, integrated operation of national power system, application of computer graphics. **PC Applications in Short Circuit Studies for Designing Relaying Scheme:** Types of faults, assumptions, development of algorithm for S.C. studies, PC based integrated software for short circuit studies, transformation to component quantities, short circuit studies of multiphase systems. Ultra high speed protective relays for high voltage long transmission line.

Total Hours:	**45**

Text Books:	
1	Singh L.P., "Digital Protection, 2nd Edition New Age International (P) Limited, New Delhi,1997
2	Paithankar and Bhide, "Fundamentals of Power System Protection", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd edition,2010.
Reference Books:	
1	Paithankar, "Transmission Network Protection", Marcel & Dekker, New York,1998.
2	Stanley Horowitz, "Protective Relaying for Power System II", John Wiley & sons, 2008
3	Rao T.S.M., "Digital Relay / Numerical relays", Tata McGraw Hill, New Delhi,2005.
Web References:	
1	https://nptel.ac.in/downloads/108101039/
Online Resources:	
1	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-061-introduction-to-electric-power-systems-spring-2011/
2	https://www.coursera.org/browse/physical-science-and-engineering/electrical-engineering?languages=en

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	2	2	2	3	3	3
CO2	3	2	2	3	3	3
CO3	3	2	2	3	3	3
CO4	2	2	2	3	3	3
CO5	2	2	2	3	3	3

25PPS202	POWER SYSTEM DYNAMICS AND STABILITY	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	: Advanced Power system Analysis	

Course Objectives:

To provide depth knowledge about Interpretation of power system dynamic phenomena and to information about various forms of stability

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the concepts and significance of dynamic analysis of a system	U
CO2	Develop modeling of power system components to learn the dynamic behavior of the system.	U
CO3	Articulate the response of power system under normal/abnormal operating conditions.	U
CO4	Interpret the concept of various Power System Models	U
CO5	Understand the concepts the stability issues in the power system	U

Course Contents:

MODULE 1 ANALYSIS OF DYNAMICAL SYSTEMS **15 Hours**

Concept of Equilibria, Small and Large Disturbance Stability, Example: Single Machine Infinite Bus System, Modal Analysis of Linear Systems, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff Systems.

MODULE 2 MODELING OF POWER SYSTEM COMPONENTS **18 Hours**

Synchronous machine : Physical Characteristics, Rotor Position Dependent model, D-Q Transformation, Model with Standard Parameters, Steady State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Synchronous Machine Connected to Infinite Bus. Excitation System: Physical Characteristics and Models, Control system components, Excitation System Controllers, Prime mover system: Prime Mover Control Systems. Transmission lines: Transmission Line Physical Characteristics, Transmission Line Modeling, Load: Load Models - Induction machine model, Other Subsystems - HVDC, protection systems

MODULE 3 STABILITY ISSUES IN INTERCONNECTED POWER SYSTEMS **12 Hours**

Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Single Machine Load Bus System: Voltage Stability, Torsional Oscillations.

Total Hours:	**45**

Text Books:	
1.	P. Kundur, “Power System Stability and Control”, McGraw Hill Inc,1994
2.	J. Machowski, Bialek, Bumby, “Power System Dynamics and Stability”, John Wiley & Sons
Reference Books:	
1.	L. Leonard Grigsby (Ed.); “Power System Stability and Control”, 2nd edition, CRC Press,2007
2.	V. Ajjarapu, “Computational Techniques for voltage stability assessment & control”; Springer,2006
Web References:	
1	https://nptel.ac.in/courses/108102080
2	https://nptel.ac.in/downloads/108101004
Online Resources:	
1	https://www.coursera.org/learn/electric-power-systems
2	https://www.coursera.org/specializations/energy-industry
3	https://www.coursera.org/learn/electricity
4	https://www.coursera.org/learn/current-control

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	2	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	2	2	2	3	3	2

25PPS203	POWER SYSTEMS SIMULATION LABORATORY	0/0/4/2
Nature of the Course	: Practical	
Pre-requisite	: Power system Analysis	

Course Objectives:

To impart knowledge in solving and analyzing power system problems using software

Course Outcomes:

Upon completion of the course, students shall have ability to

CO1	Solve load flow problems of various cases.	AN
CO2	Analyze transient stability and small signal stability of SMIB and mutimachine system using simulation tools	AN
CO3	Analyze the functions of protective relays and starting methods of induction motor using simulation tools	AN
CO4	Compute harmonics in the system using simulation tool	AP

Course Contents:

S.No.,	List of Experiments	CO Mapping	RBT
1.	Power flow analysis by Newton-Raphson method	CO1	AN
2.	Power flow analysis by Fast decoupled method	CO1	AN
3.	Transient stability analysis of single machine-infinite bus system using classical machine model	CO2	AN
4.	Small-signal stability analysis of multi-machine configuration with classical machine model	CO2	AN
5.	Co-ordination of over-current and distance relays for radial line protection	CO3	AP
6.	Analysis of Induction motor starting methods	CO3	AP
7.	Load flow analysis of two-bus system with STATCOM	CO1	AN
8.	Transient analysis of two-bus system with STATCOM	CO2	AN
9.	Available Transfer Capability calculation using an existing load flow program	CO1	AP
10.	Computation of harmonic indices generated by a rectifier feeding a R-L load	CO4	AP
		Total Hours:	45

Text Books:

1. G W Stagg, A.H El. Abiad “Computer Methods in Power System Analysis”, McGraw Hill, 2017
2. P.Kundur, “Power System Stability and Control”, Mc Graw Hill,1994

Reference Books:

1. A.J.Wood and B.F.Wollenberg, “Power Generation Operation and Control”, John Wiley and sons, New York,1996.
2. W.F.Tinney and W.S.Meyer, “Solution of Large Sparse System by Ordered Triangular Factorization” IEEE Trans. on Automatic Control, Vol: AC-18, pp:333-346, Aug1973.
3. K. Zollenkopf, “Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96; Book on “Large Sparse Set of Linear Systems”1st Editor: J.K. Rerd, Academic Press, 1971.

Web References:

1	https://nptel.ac.in/courses/108105067
2	https://freevideolectures.com/course/2353/power-systems-analysis

Online Resources:

1	https://www.coursera.org/learn/electric-power-systems
2	https://www.coursera.org/specializations/energy-industry
3	https://www.coursera.org/learn/current-control
4	https://www.coursera.org/learn/electricity

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2

25PPS204	POWER SYSTEM DYNAMICS LABORATORY	0/0/4/2

Nature of the Course : Practical

Pre-requisite : Advanced Power system Analysis

Course Objectives:

To impart knowledge in solving and analyzing power system problems and research oriented problems using software tools.

Course Outcomes:

Upon completion of the course, students shall have ability to

CO1	Determine the matrix model of a system	[AP]
CO2	Develop the dynamic modeling of machines using simulation tools	[AN]
CO3	Analyze the short circuit and stability conditions of the power system	[AN]
CO4	Determine the voltage regulation and power angle curves of the system under specific condition	[AP]
CO5	Analyze the solar panel output at various condition	[AN]

Course Contents:

S.No.,	List of Experiments	CO Mapping	RBT
1.	Formation of Bus Admittance and Impedance Matrices.	CO1	AP
2.	Modeling of Induction machine	CO2	AP
3.	Modeling of synchronous machine	CO2	AP
4.	Transient and small signal stability of single machine infinite bus system	CO3	AP
5.	Transient and small signal stability of multi machine infinite bus system	CO3	AP
6.	Fault Analysis with Relay Settings	CO3	AP
7.	Determination of Voltage Regulation	CO4	AP
8.	Simulation of Power angle Curves	CO4	AP
9.	Study of effect of Temperature on Solar Panel Output	CO5	U
10.	Characteristics of Solar Panel Output	CO5	AP
		Total Hours:	**60**

Text Books:
1. Padiyar K.R., "Power System Dynamics, Stability & Control", 2nd Edition, B.S. Publications, Hyderabad, 2008 2. P.Kundur, "Power System Stability and Control", McGraw Hill Inc.,1994 3. Sauer P. and Pai M.A., "Power System Dynamics and Stability", Prentice Hall,2006
Reference Books:
1. Ramanujam,R. "Power System Dynamics: Analysis and Simulation", PHI Learning Pvt. Ltd., 2010 2. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi,1981 3. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons,1997 4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

Web References:	
1	https://www.youtube.com/watch?v=-xFq5QXYfwc
2	https://www.youtube.com/watch?v=dNV6UiFrI10
3	https://www.youtube.com/watch?v=PAKc6ZURAn4

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	**2**	**2**	**3**		**3**	**2**
CO2	**2**	**2**	**3**		**3**	**2**
CO3	**3**	**2**	**3**	**3**	**3**	**2**
CO4	**2**	**2**	**3**	**2**	**3**	**2**
CO5	**3**	**2**	**3**	**3**	**3**	**2**
CO6	**2**	**2**	**3**		**3**	**2**

25PPSE01	MODERN POWER GENERATION	3/0/0/3
Nature of the Course	: Theory	
Pre-request	:Nil	

Course Objectives:

1. To gain knowledge on bio energy generation and utilization
2. To get an exposure on various renewable power generation schemes and production of energy from Solar Photovoltaic systems, geothermal, ocean and fuel cells.
3. To learn about energy storage and hybrid systems

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand bio energy generation and utilization	U
CO2	Design, develop and assess solar thermal systems and Solar Photovoltaic systems	AP
CO3	Formulate protocol to convert agricultural waste into energy.	U
CO4	Estimate energy generated from sources like ocean , hydrogen and geothermal	U
CO5	Develop a model on hybrid Renewable systems	AP

Course Contents:

MODULE 1 Renewable Energy Policy and Legislation **10 Hours**

Rural Energy - Biogas plants - Improved biomass cooking stoves - Biomass production and utilization – briquetting and gasifiers - Integrated Rural Energy Programme.

MODULE 2 Solar Energy and power generation from renewable sources **18 Hours**

Solar Photovoltaic systems - Solar thermal systems - Solar thermal power generation schemes - Solar Energy Centre- Thermal analysis of solar power plants. Solar photovoltaic Power – Solar Thermal Power.

MODULE 3 Power Generation and Energy Storage **17 Hours**

Biomass Power - Energy from Urban, Municipal and Industrial Wastes- Wind Power - Small Hydro Power - Geothermal energy - ocean energy - alternate fuel for surface transport including electric vehicles - chemical sources of energy including fuel cells and hydrogen energy. Energy storage Technologies – Battery–Hybrid Renewable systems–Case studies on Hybrid photovoltaic/thermal systems and Solar-wind hybrid systems.

Total Hours:	**45**

Text Books:	
1	G. D. Rai, “Non Conventional Energy Sources”, ISBN: 8174090738, Khanna Publishers. (2010)
2	Rao S, Parulekar BB. Energy Technology: Non-conventional, Renewable and Conventional, Khanna Pub. (2005
Reference Books:	
1	Goswami DY, Krieth F and Krieder JF, Principles of Solar Engineering, 2nd edition, Taylor and Francis Inc.(2000)
2	Tiwari GN, Solar Energy, Narosa Publisers, (2002).
3	Garg HP and Prakash J, Solar Energy – Fundamentals and Applications, Tata McGraw-Hill,(2004).
4	Manwell JF and Roger AL, Wind Energy: Theory, Design and Applications, Wiley Inc.,(2008).
5	Dickson MH, Geothermal Energy: Utilization and Technology, UNESCO(2005)
6	Charlier RH, Ocean Energy: Tidal and Tidal Power, R.H. Charlier, Springer-Verlag (2004)
Web References:	
1	https://nptel.ac.in/courses/121106014/
2	https://nptel.ac.in/courses/108108078/
Online Resources:	
1	https://www.coursera.org/learn/future of energy
2	https://www.coursera.org/learn/ sustainability/renewable-energy
3	https://www.coursera.org/lecture/global-energy
4	https://www.mooc-list.com/tags/renewable-energy

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	**3**	**2**	**3**	**3**	**3**	**2**
CO2	**3**	**2**	**3**	**3**	**3**	**2**
CO3	**3**	**2**	**3**	**3**	**3**	**2**
CO4	**3**	**2**	**3**	**3**	**3**	**2**
CO5	**3**	**2**	**3**	**3**	**3**	**2**

25PPSE02	SMART GRID	3/0/0/3

Nature of the Course	: Theory
Pre-requisite	:Nil

Course Objectives:

1. To study about Smart Grid technologies, different smart meters and advanced metering infrastructure
2. To familiarize the power quality management issues in Smart Grid
3. To impart knowledge on high performance computing for Smart Grid applications

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the concepts of Smart Grid and its present developments	U
CO2	Understand about different Smart Grid technologies.	U
CO3	Interpret different smart meters and advanced metering	AP
CO4	Illustrate the power quality management and its issues in Smart Grids	AP
CO5	Understand the LAN, WAN and Cloud Computing for Smart Grid applications	U

Course Contents:

MODULE 1 Introduction to Smart Grid Technologies 15 Hours

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid Smart Grid Technologies **-** Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV)

MODULE 2 Advanced Metering Infrastructure and Power quality management 15 Hours

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection. Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit

MODULE 3 High Performance Computing For Smart Grid Applications 15 Hours
- Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid

Total Hours:	**45**

Text Books:	
1	Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, AkihikoYokoyama, "Smart Grid: Technology and Applications", Wiley2012.
2	Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions". CRC Press2012
3	James Momoh, ― SMART GRID : Fundamentals of Design and Analysis‖, John Wiley and Sons, New York,2012
Reference Books:	
1	Smart Grid Primer‖, Published by Power Grid Corporation of India Limited, September 2013.
2	Fereidoon.P.Sioshansi, ―Smart Grid – Integrating Renewable, Distributed and Efficient Energy‖, Academic Press,2011
3	Seth Leitman, "Build Your Own Electric Vehicle" MC Graw hill, New York, USA2013
4	JanakaEkanayake,NickJenkins,KithsiriLiyanage,JianzhongWu,AkihikoYokoyama, ―Smart Grid: Technology and Applications‖, John Wiley & Sons, New Jersey, 2012.
Web References:	
1	https://www.energy.gov/oe/downloads/smart-grid-introduction
2	https://onlinecourses.nptel.ac.in/noc18_ee42
3	https://www.ieee-pes.org/presentations/gm2014/PESGM2014P-001876.pdf

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	3

25PPSE03	TRANSDUCERS AND SMART INSTRUMENTS	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To give an overview of the working and characteristics of conventional transducers
2. To provide an exposure of latest trends in sensor technologies including multi-sensor data fusion.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Compare conventional transducers and select the suitable one for the given Application	U
CO2	Study and quantify the uncertainties in measurement data.	U
CO3	Design and develop customized smart sensors for different applications	AP
CO4	Acquire a comprehensive knowledge of manufacturing techniques and design aspects of micro sensors and actuators	AP
CO5	Understand latest sensor technology and advanced measurement methodologies.	U

Course Contents:

MODULE 1 Overview of conventional transducers and their Characteristics 12 Hours
Overview of conventional sensors - Resistive, Capacitive, Inductive, Piezoelectric, Magnetostrictive and Hall effect sensors - Static and Dynamic Characteristics and specifications.

MODULE 2 Measurement Error and Uncertainty Analysis 18 Hours
Importance of error analysis - Uncertainties, precision and accuracy in measurement – limiting error and probable error - Random errors - Distributions, mean, width and standard error - Uncertainty as probability - Gaussian and Poisson probability distribution functions, confidence limits, error bars, and central limit theorem - Error propagation - single and multivariable functions, propagating error in functions **Smart Sensors:** Definition – Integratedsmartsensors–sensingelements–designofInterfaceelectronics-parasiticeffects– sensor linearization - Dynamic range - Universal Sensor Interface – front end circuits - DAQ – Design – Digital conversion - Microcontrollers and digital signal processors for smart sensors – selection criteria - Timer, Analog comparator, ADC and DAC modules - Standards for smart sensor interface.

MODULE 3 Micro sensors and actuators 15 Hours
Micro system design and fabrication – Micro pressure sensors (Piezo resistive and Capacitive) – Resonant sensors – Acoustic wave sensors – Bio micro sensors – Micro actuators – Micro mechanical motors and pumps- Introduction to Nano sensors. **Recent Trends In Sensor Technologies:** Thick film and thin film sensors- Electro chemical sensors – RFIDs - Sensor arrays – Sensor network – Multi sensor data fusion - Soft sensor.

Total Hours:	**45**

Text Books:	
1	D. Patranabis, “Sensors and Transducers”, Second Edition, PHI,2004
2	Gerord C.M. Meijer, “Smart Sensor Systems, John Wiley and Sons,2008
Reference Books:	
1	Ernest O Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 5 th Edition, Tata Mc-Graw Hill,2011
2	Ifan G. Hughes and Thomas P.A. Hase, “Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis”, Oxford University Press, 2010
3	Tai-Ran Hsu, “Mems and Micro Systems: Design and Manufacture, Tata McGraw Hill, 2002
Web References:	
1	https://nptel.ac.in/courses/108105064/34
2	https://nptel.ac.in/courses/108105064/
3	https://nptel.ac.in/courses/112108092/
Online Resources:	
1	https://www.coursera.org/lecture/internet-of-things-sensing-actuation/whats-in- sensor-9Fv3d
2	https://www.coursera.org/lecture/nanotechnology1/components-and-classification-of-sensors-JkPX3
3	https://www.coursera.org/lecture/intelligent-machining/sensors-2w3Am

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	2	2	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	2	2	3	3	2
CO5	3	2	2	3	3	3

25PPSE04	SOLAR AND ENERGY STORAGE SYSTEMS	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	: Nil	

Course Objectives:

1. To provide depth knowledge about solar modules, grid connected PV systems, PV system design
2. To learn about different energy storage systems and their applications.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand fundamentals of solar and energy storage systems	U
CO2	Illustrate the available solar energy and the current solar energy conversion and utilization processes	AP
CO3	Discuss semiconductor physics, optical systems, load matching, and storage and grid connections related to photovoltaic engineering	U
CO4	Analyze the challenges in sustainable energy processes, cost analysis calculation, photovoltaic design for different applications meeting residential and industrial needs.	AN
CO5	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials of solar energy utilization.	U

Course Contents:

MODULE 1 INTRODUCTION **12 Hours**
Introduction: Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

MODULE 2 SOLAR PV SYSTEM **18 Hours**
Stand alone PV system: Solar modules – storage systems– power conditioning and regulation - protection –– stand alone PV–– systems design –– sizing. Grid connected PV systems: PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

MODULE 3 ENERGY STORAGE SYSTEM AND APPLICATIONS **15 Hours**
Energy storage systems: Impact of intermittent generation – Battery energy storage – solar thermal energy storage –pumped hydroelectric energy storage Applications: Water pumping – battery chargers – solar car – direct-drive applications –Space Telecommunications.

Total Hours: 45

Text Books:

1. Solar Cells: Operating Principles, Technology and System Applications, Martin Green Published by the University of New South Wales,1980.
2. Photovoltaic Science and Engineering Handbook, Second Edition, Antonio Luque and Steven Hegedus, John Wiley and Sons,2012

Reference Books:

1. EduardoLorenzoG.Araujo,"Solar electricity engineering of photovoltaic systems", Progensa,1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics", Earthscan, UK, 2007.
3. Frank S. Barnes and Jonah G. Levine, "Large Energy Storage Systems Handbook", CRC Press, 2011.
4. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern,1995.
5. S.P. Sukhatme, "Solar Energy", Tata McGrawHill,1987.

Web References:

1	https://nptel.ac.in/courses/112105050/m1l1
2	https://nptel.ac.in/courses/108105058/37

Online Resources:

1	https://www.pveducation.org
2	https://www.heatspring.com/courses/designing-pv-systems-with-energy-storage
3	https://www.coursera.org/learn/solar-cells

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE05	ELECTRICAL POWER DISTRIBUTION SYSTEM	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To provide the fundamental principles of the electric power delivery system with emphasis on distribution systems.
2. To learn the modeling of distribution system components
3. To impart knowledge on metering and billing in distribution system

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the structure and load patterns of a power distribution system	U
CO 2	Understand the transition of distribution system from passive to active with the adoption of distributed generation, storage, and smart-grid technologies	U
CO 3	Analyze the modelling of the components like feeders, distribution transformer, regulators, capacitors, loads, distributed generation, storage, etc	AP
CO 4	Analyzing the power loss, fluctuations and breakdown in the distribution system.	AP
CO 5	Illustrate the metering & billing, cost estimation, tariff and energy accounting and billing.	AP

Course Contents:

MODULE 1: LOAD FORECASTING AND COMPONENTS OF DISTRIBUTION SYSTEM **15 Hours**

Load forecasting, Power Quality parameters, Choice of systems for different consumers, Planning Criteria, Standards, System layout. Towers/Poles, Stay wires; Conductor Types, Characteristics & selection; Underground Cables -Selection, laying, cable box and jointing; Earth wire; Insulators & hardware fittings; Distributors, Feeders, Services Mains (LV, MV, HV); Clearances; Pole-mounted sub-stations and its location; Earthing HT & LT poles/supports. Types, General Arrangement, Layout, Bus-bar arrangements

MODULE 2: SUB-STATION EQUIPMENT **18 Hours**

Sub-station equipment – Construction details, selection and specification of equipment (distribution transformer, Circuit Breakers, etc.); Auxiliary Systems; Earthing of sub-station equipment. Classification, Causes and Calculation of power losses; Methods of reducing power losses; Causes and cures for breakdowns, tripping and fluctuations in distribution system; System voltage drops and improvements; Distribution transformer failures –causes & remedies.

MODULE 3: METERING AND BILLING **12 Hours**

Meters/Indicators –Types & Function; Latest development in metering technologies, Cost Engineering, Costing & Control, Estimation, Estimate for providing service(LT/HT) connections; Tariff structure & Types, Rational & Competitive tariff, Energy Accounting and Energy Billing.

Total Hours:	**45**

Text Books:	
1. Electric Power Distribution Engineering/ Turan Gonen /Mc Graw Hill. 2. Power Distribution Engineering: Fundamentals and Applications/ Burke James, J./ Marcel Dekker Inc./1996.	
Reference Books:	
1. Power Distribution Planning Reference Book/ H. Lee Willis/ Marcel Dekker, Inc. 2. Modern Trends and Practices in Power Sub-Transmission and Distribution Systems/Volumes I & II, / N. K. Jangalwa / Central Board of Irrigation and Power/1996. 3. Electric Distribution System ,A. A. Sallam and O. P. Malik, IEEE Press, Piscataway, NJ, 2011.	
Web References:	
1	https://nptel.ac.in/courses/108106025
2	https://onlinecourses.nptel.ac.in/noc18_ee15/course
Online Resources:	
1	https://www.coursera.org/specializations/energy-industry
2	https://www.coursera.org/learn/electric-power-systems

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE06	PULSE WIDTH MODULATION FOR PE CONVERTERS	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Power Electronics	

Course Objectives:

1. To impart knowledge on different converter topologies
2. To know about the different types of Pulse width modulation techniques for various Power electronic converters

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand Converter topologies for AC/DC and DC/AC power conversion, overview of applications of voltage source converters	U
2	Analyze pulse width modulation techniques for 1-phase and 3-phase bridge converters	AP
3	Analyze about sine-triangle PWM, bus clamping PWM, space vector based PWM, advanced PWM techniques	AP
4	Analyze estimation of current ripple and torque ripple in inverter fed drives	AP
5	Summarize the extension of modulation methods to multilevel inverters.	U

Course Contents:

Module 1: DC-DC Converters and Harmonic Analysis **15 Hours**

Electronic switches, dc-dc buck and boost converters, H-bridge, multilevel converters – diode clamp, flying capacitor and cascaded-cell converters; voltage source and current source converters; evolution of topologies for dc-ac power conversion from dc-dc converters. Review of Fourier series, fundamental and harmonic voltages; machine model for harmonic voltages; undesirable effects of harmonic voltages –line current distortion, increased losses, pulsating torque in motor drives; control of fundamental voltage; mitigation of harmonics and their adverse effects.

Module 2: Inverters and its Losses **15 Hours**

Square wave operation of voltage source inverter, PWM with a few switching angles per quarter cycle, equal voltage contours, selective harmonic elimination, THD optimized PWM, off-line PWM-Synchronously revolving reference frame; error between reference voltage and applied voltage, integral of voltage error; evaluation of line current ripple; hybrid PWM for reduced line current ripple Relation between line-side currents and dc link current; dc link current and inverter state; rms dc current ripple over a carrier cycle; rms current rating of dc capacitors Simplifying assumptions in evaluation of inverter loss, dependence of inverter loss on line power factor, influence of PWM techniques on switching loss, design of PWM for low inverter loss.

Module 3: Dead-time compensation and Vector Analysis **15 Hours**

Requirement of dead-time, effect of dead-time on line voltages, dependence on power factor and

modulation method, compensation of dead-time effect. Per-phase and space vector approaches to over-modulation, average voltages in a synchronously revolving *d-q* referenceframe,low-frequencyharmonicdistortion.Extensionsofsine-trianglePWMtomultilevel inverters, voltage space vectors, space vector based PWM, analysis of line current ripple and torque ripple.	
Total Hours:	**45**

Text Books:	
1. Pulse Width Modulation for Power Converters: Principles and Practice by D. Grahame Holmes , Thomas A. Lipo	
Reference Books:	
1. Pulse-width Modulated DC-DC Power Converters by Marian K.Kazimierczuk 2. Power Electronic Converters: PWM Strategies and Current Control Techniques by Eric Monmasson	
Web References:	
1	https://nptel.ac.in/courses/108108035/
Online Resources:	
1	https://globaledx.com/Pulse-width-Modulation-for-Power-Electronic-Converters

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE07	ELECTRIC AND HYBRID VEHICLES	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To present a comprehensive overview of Electric and Hybrid Electric Vehicles
2. To learn on various energy storage systems

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Choose a suitable drive scheme for developing an electric hybrid vehicle	AP
CO2	Design and develop basic schemes of electric vehicles and hybrid electric vehicles	AP
CO3	Choose proper energy storage systems for vehicle applications	AP
CO4	Interpret various communication protocols and technologies used in vehicle networks	AP
CO5	Choose electric drive and controller for the efficient design of an electric vehicle	AP

Course Contents:

MODULE 1: INTRODUCTION **12 Hours**

Electric Vehicle History - Components of Electric Vehicle - Comparison with Internal combustion Engine : Technology - Comparison with Internal combustion Engine: Benefits and Challenges - EV classification and their electrification levels - EV Terminology

MODULE 2: ELECTRIC VEHICLE TORQUE CALCULATIONS AND ARCHITECTURE **18 Hours**

Motor Torque Calculations For Electric Vehicle - Calculating the Rolling Resistance - calculating the grade resistance -Calculating The Acceleration Force - Finding The Total Tractive Effort - Torque Required On The Drive Wheel - Electric Vehicle Architecture Design **-** Types of Electric Vehicle and components - Electrical protection and system requirement - Photovoltaic solar based EV design - Battery Electric vehicle (BEV) - Hybrid electric vehicle (HEV) - Plug-in hybrid vehicle (PHEV) - Fuel cell electric vehicle (FCEV) - Electrification Level of EV - Comparison of fuel vs Electric and solar power - Solar Power operated Electric vehicles.

MODULE 3: ELECTRIC DRIVE CONTROLLER AND ENERGY STORAGE SYSTEMS **15 Hours**

Electric Drive and controller - Types of Motors - Selection and sizing of Motor - RPM and Torque calculation of motor - Motor Controllers - Component sizing - Physical locations - Mechanical connection of motor - Electrical connection of motor - Energy Storage Solutions(ESS) & Battery Management System(BMS) - Cell Types (Lead Acid/Li/NiMH) - Battery charging and discharging calculation - Cell Selection and sizing - Battery lay outing design-BatteryPackConfiguration-BatteryPackConstruction-Batteryselectioncriteria- Need of BMS - Rule based control and optimization based control - Software-based high level supervisory control - Mode of power - Behavior of motor - Advance Features

Total Hours:	**45**

Text Books:

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, New York, 2011.

Reference Books:

1. Seref Soylu "Electric Vehicles - The Benefits and Barriers", In Tech Publishers, Croatia, 2011.
2. Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi,2007
3. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.
4. Seth Leitman, "Build Your Own Electric Vehicle" MC Graw hill, New York, USA2013.

Web References:

1	https://nptel.ac.in/syllabus/108103009/

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE08	Power Electronics for Renewable Energy Systems	3/0/0/3

Nature of the Course	:Theory
Pre-requisite	: -

Course Objectives:

1. To provide knowledge about different types of renewable energy systems.
2. To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
3. To design a power converter used in renewable energy systems such as AC-DC, DCDC, and AC-AC converters.
4. To understand the importance of standalone, grid connected, and hybrid operation in renewable energy systems.
5. To analyze various maximum power point tracking algorithms.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Analyze the impacts of renewable energy technologies on the environment and demonstrate them to harness electrical power.	A
CO 2	Select a suitable Electrical machine for Wind Energy Conversion Systems.	U
CO3	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Solar energy systems.	AP
CO 4	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Wind energy systems.	AP
CO 5	Interpret the stand-alone, grid-connected, and hybrid renewable energy systems with MPPT.	A

Course Contents:

Module 1: Electrical Machines for Wind Energy Conversion Systems (WECS) 15 Hrs
Introduction to renewable Energy systems - Review of reference theory fundamentals Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

Module 2: Power Converters and Analysis of Solar PV and Wind Systems 15 Hrs
Power Converters solar PV systems: Line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems - Grid Connection Issues. Power Converters for WECS: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters - Matrix converter. Analysis: Stand-alone operation of fixed and variable speed WECS-Grid integrated SCIG and PMSG based WECS.

Module 3 Hybrid Renewable Energy Systems 15 Hrs
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind - PV, Microhydel - PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).

Total Hours:	**45**

Text Books:

1. B.H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017.
2. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009
3. Rai. G.D, “Non-conventional energy sources”, Khanna publishers, 2010.

Reference Books:

4. Rashid .M. H “Power electronics Hand book”, Academic press,2nd Edition, 2006.
5. Gray, L. Johnson, ” Wind Energy Systems”, prentice hall of india, 1995.

Web References:

1	http://unfccc.int/kyoto_protocol/items/2830.php

Online Resources:

1	https://www.coursera.org/learn/wind-energy
2	https://www.edx.org/course/solar-energy-delftx-et3034x-0

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	3	3	3	3	
CO2	3	2	2	3	2	
CO3	3	2	1	3	2	
CO4	3	2	2	3	2	
CO5	3	2	1	3	2	

25PPSE09	POWER QUALITY	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	:Nil	

Course Objectives:

- To provide knowledge of different Sources of sags, interruptions, harmonic distortion and power quality monitoring.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand different Sources of sags and interruptions and estimate voltage sag performance.	U
CO2	Enlighten different sources of over voltages, surge arrestors, filters and power conditioners	AP
CO3	Explain harmonic distortion and power quality monitoring	AP
CO4	Understand the usage of FACTS devices to mitigate power quality problems	U

Course Contents:

MODULE 1 INTRODUCTION TO POWER QUALITY **15 Hours**
Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

MODULE 2 CAUSES OF POWER QULAITY ISSUES IN POWER SYSTEM **15 Hours**
Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives. Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace’s, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform. Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices –

MODULE 3 VOLTAGE SAG **15 Hours**
Analysis of voltage sag: Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction. Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

Total Hours:	**45**

Text Books:
1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices",Kluwer Academic Publishers,01-Jan-2002. 2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition). 3. R.C. Duggan," Electrical Power System Quality", Tata Mcgraw Hill, 3rd edition2012.
Reference Books:
1. Arrillga. A.J and Neville R. Watson," Power System Harmonics", John Wiley 2nd Edition, 2003. 2. Derek A. Paice, "Power electronic converter harmonics", John Wiley & sons,1999.

Web References:

1	https://nptel.ac.in/courses/108106025

Online Resources:

1	http://www.btstraining.com/229-power_quality.html
2	https://www.tdpowerskills.com/courses/overhead-deenergized/power-quality
3	https://easyengineering.net/electrical-power-systems-quality-by-dugan/
4	http://powerqualitytraining.com/

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	**3**	**2**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**3**	**3**	**3**
CO3	**3**	**2**	**3**	**3**	**3**	**3**
CO4	**3**	**2**	**3**	**3**	**3**	**3**

5PPSE10	DYNAMICS OF ELECTRICAL MACHINES	3/0/0/3
Nature of the Course	**:Theory**	
Pre-requisite	**:Nil**	

Course Objectives:

1. To impart knowledge on dynamic modeling, simulation and control theory for electric machinery and associated power electronic drive systems that find a wide range of applications in electric power engineering careers.
2. To understand the mathematical model of synchronous machines and induction motors.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Derive Kron's Primitive machine as an unified electrical machine model	**U**
CO2	Analyze the mathematical model and control a 3- phase Induction motor	**AP**
CO3	Analyze asymmetrical 2-phase induction motor	**AP**
CO4	Analyze the mathematical model of a Phase Salient Pole Synchronous Machine	**AP**
CO5	Analyze the dynamical Interconnected Machines	**AP**

Course Contents:

MODULE 1 : Electro dynamical Equations and their Solution 15 Hours
A Spring and Plunger System- Rotational Motion System. Mutually Coupled Coils. Lagrange's Equation. Application of Lagrange's Equation to Electromechanical Systems. Solution of Electrodynamical Equations by Euler's method and Runge- Kutta method. Linearization of the Dynamic Equations and Small Signal Stability. Differential Equations of a smooth air-gap two winding machine. Conditions for Conversion of Average Power in such a Machine. The Primitive 4 Winding Commutator Machine- The Commutator Primitive Machine. The Brush Axis and its Significance. Self and Mutually induced voltages in the stationary and commutator windings. Speed e.m.f induced in Commutator Winding. Rotational Inductance Coefficients. Sign of Speed e.m.f terms in the Voltage Equation.

MODULE 2 : Three Phase Induction Motor 15 Hours
Equivalent Two Phase Machine by mmf equivalence. Equivalent two phase machine currents from three phase machine currents. Power Invariant Phase Transformation. Voltage Transformation. Voltage and Torque Equations of the Equivalent Two Phase Machine. Commutator Transformation and its interpretation. Transformed Equations. Different Reference Frames for Induction Motor Analysis. Nonlinearities in Machine Equations. Equations under Steady State - Solution of Large Signal Transients in an Induction Machine. Linearized Equations of Induction Machine. Small Signal Stability, Eigen values, Transfer function formulation.

MODULE 3: Three Phase Salient Pole Synchronous Machine 15 Hours
Three Phase to Two Phase Transformation. Voltage and Torque Equations in stator, rotor and air-gap field reference frames. Commutator Transformation and Transformed Equations. Parks Transformation. Suitability of Reference Frame Vs. kind of Analysis to be Carried out. Steady State Analysis. Large Signal Transient Analysis. Linearization and Eigen Value Analysis. General

Equations for Small Oscillations. Small Oscillation Equations in State Variable form. Damping and Synchronizing Torques in Small Oscillation Stability Analysis. Application of Small Oscillation Models in power system models. Dynamical Analysis of Interconnected Machines: Machine Interconnection Matrices. Transformation of Voltage and Torque Equations using Interconnection Matrix. Large Signal Transient Analysis using Transformed Equations. Small Signal Model using Transformed Equations. The DC Generator/DC Motor System. The Alternator /Synchronous Motor System. The Ward-Leonard System. Hunting Analysis of Interconnected Machines Selection of proper reference frames for individual machines in an Interconnected System.	
Total Hours	**45**

Text Books:

1. R. Krishnan “Electric Motor Drives - Modeling, Analysis & control” –Pearson Publications-1st edition-2002
2. P.C. Krause, Oleg Wasynczuk, Scott D. Sudhoff “Analysis of Electrical Machinery and Drive systems” — Second Edition-IEEE Press

Reference Books:

1. Chee Mun Ong “Dynamic simulation of Electric machinery using Matlab / Simulink” – Prentice Hall
2. D.P. Sengupta & J.B. Lynn : “Electrical Machine Dynamics”, The Macmillan Press Ltd.
3. C.V. Jones, “The Unified Theory of Electrical Machines” Butterworth, London.
4. Woodson & Melcher, “Electromechanical Dynamics”, John Wiley & Sons.

Web References:

1	https://nptel.ac.in/courses/108106023/
2	https://nptel.ac.in/syllabus/108104011/

Online Resources:

1	https://www.coursera.org/learn/research-methods
2	https://www.coursera.org/learn/protect-business-innovations-patent
3	http://www.wipo.int/academy/en/courses/distance_learning
4	http://www.ccrm.in/

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2

25PPSE11	OPTIMAL CONTROL THEORY	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To learn the formulation of optimal control problems, method of dynamic programming, concept of functional and constrained optimization problems, the pontryagin's principle
2. To solve regulator problem and optimal control problems

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Develop optimal control problems	AP
CO2	Solve optimal control problems using dynamic programming	AP
CO3	Solve minimum time/minimum control effort problems	AP
CO4	Apply pontryagin's principle for solving regulator problem	AP
CO5	Solve optimal control problem using numerical methods	AP

Course Contents:

MODULE 1 Performance Measure **15 Hours**

Problem formulation - state variable representation of systems – performance measures for optimal control problems - selecting a performance measure. Dynamic Programming: Optimal control law – principle of optimality – Application of Principle of optimality to decision making – Recurrence relation of Dynamic Programming – Imbedding Principle – computational procedure to solve optimal control problems – Discrete Linear regulator Problems – Hamilton – Jacobi Belman Equation – Continous linear regulator problems.

MODULE 2 Calculus of Variations **15 Hours**
Fundamental concepts – Functional of a single function – functionals involving several independent functions – piece wise smooth extremals – constrained extrema.

MODULE 3 Variational Approach to Optimal Control Problem **15 Hours**
Necessary condition for optimal control – Linear regulator problems – Pontryagin's Minimum Principle and state inequality constraints – Minimum time Problems –Minimum Control – Effort problems – Singular intervals in optimal control Problem Numerical Methods of Optimal Control : Simplex Method – golden section Method – Hill climbing – Gradient – Penalty functions methods

Total Hours:	**45**

Text Books:

1. Donald. E. Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc., Englewood Cliffs, New Jersey,1962.
2. 2. Brain D. O. Anderson and J. B. Moore, Optimal control, Prentice Hall,1990.

Reference Books:

1. Andrew P. Sage, Optimum Systems Control, Prentice Hall N.H.1968
2. Michael Athans and Peter L Falb, Optimal control, Dover publications,2006.
3. Rao S.S., Optimization Theory and Application, Wiley Eastern, New Delhi,1992

Web References:

1	https://nptel.ac.in/courses/108105019/
2	https://onlinecourses.nptel.ac.in/noc17_ee11/preview
3	https://nptel.ac.in/courses/108103008/38

Online Resources:

1	https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-323-principles-of-optimal-control-spring-2008/
2	https://www.coursera.org/lecture/nonlinear-spacecraft-attitude-control/1-lyapunov-optimal-control-5uIFA

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	2	2	1	2	2	2
CO2	3	1	1	2	2	2
CO3	2	1	1	2	2	2
CO4	2	1	1	2	2	2
CO5	3	1	1	2	2	2

25PPSE12	RENEWABLE ENERGY SYSTEM	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	: Nil	

Course Objectives:

1. To provide knowledge about the concepts of Non-renewable and renewable energy systems.
2. To impart knowledge on utilization of renewable energy sources for both domestic and industrial applications.
3. To acquire an awareness on environmental and cost economics of renewable energy sources in comparison with fossil fuels.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the energy scenario in India and Integrated Resource Plan	**U**
CO2	Understand adequate Objective of the solar energy conversion systems and applications	**U**
CO3	Understand the various operating modes of wind generating systems, installations and its application	**U**
CO4	Understand basic knowledge in importance of biogas and biomass Plants	**U**
CO5	Understand the concepts of ocean energy	**U**

Course Contents:

MODULE 1: Global and National Energy Scenario **15 Hours**

Over view of conventional & renewable energy sources - Need & development of renewable energy sources - Types of renewable energy systems - Future of Energy Use - Global and Indian Energy scenario - Renewable and Non- renewable Energy sources, Energy for sustainable development - Potential of renewable energy sources - Renewable electricity and key elements – Global climate change.

MODULE 2: Solar and Wind Energy **15 Hours**

Solar energy system - Solar Radiation – Availability - Measurement and Estimation - Solar Thermal Conversion Devices and Storage **Wind Energy:** Wind Energy Conversion – Potential - Wind energy potential measurement - Site selection - Types of wind turbines - Wind farms – Wind Generation and Control - Nature of the wind - Power in the wind - Factors influencing wind – Wind data and energy estimation - Wind speed monitoring - Classification of wind–Characteristics- Applicationsofwindturbines-Offshorewindenergy–Hybrid systems - Wind resource assessment - Betz limit – Site selection - Wind energy conversion devices - Wind mill component design – Wind energy potential and installation in India.

MODULE 3: Biogas and Ocean Energy **15 Hours**

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features – Biomass resources and their classification -

Biomass conversion processes – Thermo chemical conversion - Direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Biodiesel production **Ocean Energy:** Ocean wave energy conversion - Principle of Ocean Thermal Energy Conversion(OTEC)- Ocean thermal power plants- Tidal energy conversion- Tidal and wave energy its scope and development - Scheme of development of tidal energy.

Total Hours: 45

Text Books:

1. John Twidwell and Tony Weir, “Renewable Energy Resources”, 3rd Edition, Routledge, 2015.
2. Rai, G.D, “Non Conventional Energy Sources”, Khanna Publishers,2010.

Reference Books:

1. Aldo Vieira Da Rosa, “Fundamentals of Renewable Energy Processes”, Academia Press,2012.
2. B.H. Khan, “Non-Conventional Energy Resources”, 2nd Edition, Tata McGraw Hill, New Delhi,2010.
3. G.N. Tiwari, “Solar Energy”, Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2009.

Web References:

1	http://nptel.ac.in/courses/108108078/
2	http://www.pacificorp.com/es/irp.html
3	https://www.ashden.org/files/SKG%20full.pdf

Online Resources:

1	https://www.edx.org/course/sustainable-energy-design-renewable-delftx-energyx
2	https://www.coursera.org/learn/wind-energy
3	https://www.edx.org/course/solar-energy-delftx-et3034x-0

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE13	ADVANCED DIGITAL IMAGE PROCESSING	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Digital image processing	

Course Objectives:

1. To study the image fundamentals and mathematical transforms necessary for image processing
2. To learn various image processing techniques

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand image formation and the role human visual system plays in Perception of gray and color image data.	U
2	Apply image processing techniques in both the spatial and frequency (Fourier) domains.	AP
3	Design image analysis techniques in the form of image segmentation and to evaluate the methodologies for segmentation.	AP
4	Examine the feature extraction techniques , image registration and image fusion.	AP
5	Evaluate the constraints in image processing when dealing with 3D data sets and to apply image processing algorithms in practical applications.	AP

Course Contents:

MODULE 1 FUNDAMENTALS OF DIGITAL IMAGE PROCESSING 15 Hours

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, and SVD. Image enhancement in spatial and frequency domain, Review of morphological image processing

MODULE 2 SEGMENTATION AND FEATURE EXTRACTION 15 Hours

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour methods, Texture feature based segmentation, Model based segmentation, Atlas based segmentation, Wavelet based Segmentation methods **FEATURE EXTRACTION:** First and second order edge detection operators, Phase congruency, Localized feature extraction- detecting image curvature, shape features Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features

MODULE 3 REGISTRATION , IMAGE FUSION AND 3D IMAGE VISUALIZATION 15 Hours

Registration- Preprocessing, Feature selection-points, lines, regions and templates Feature correspondence-Point pattern matching, Line matching, region matching Template matching. Transformation functions-Similarity transformation and Affine Transformation. Resampling- Nearest Neighbour and Cubic Splines Image Fusion-Overview of image fusion, pixel fusion, Multi resolution based fusion discrete wavelet transform, Curvelet transform. Region based fusion. 3D IMAGE VISUALIZATION: Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of

color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiply connected surfaces, Image processing in 3D, Measurements on 3D images.	
Total Hours:	**45**

Text Books:

1. John C.Russ, "The Image Processing Handbook", CRCPress,2007.
2. Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press, 2008.
3. Ardeshir Goshtas by, " 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications", John Wiley andSons,2005.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Pearson, Education, Inc., Second Edition,2004
2. Anil K. Jain, "Fundamentals of Digital Image Processing", Pearson Education,Inc.,2002.
3. Rick S.Blum, Zheng Liu," Multi sensor image fusion and its Applications", Taylor & Francis,2006.

Web References:

1	https://nptel.ac.in/courses/117105079/17
2	https://freevideolectures.com/course/2316/digital-image-processing-iit-kharagpur

Online Resources:

1	https://www.tutorialspoint.com/dip/
2	http://imageprocessingplace.com/root_files_V3/tutorials.htm
3	https://homepages.inf.ed.ac.uk/rbf/HIPR2/glossary.htm
4	https://www.wisdomjobs.com/e-university/digital-image-processing-tutorial-1384.html

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE14	NANOTECHNOLOGY FOR ENERGY SYSTEMS	3/0/0/3

Nature of the Course	:Theory
Pre-requisite	:Nil

Course Objectives:

1. To present the importance of the non-conventional energy and the key role played by nanotechnology in developing the system
2. To understand the significance of nanotechnology in improving energy efficiency

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the basic concepts involved in energy systems and to explore applications of nanotechnology.	U
CO2	Analyze the various nano materials researched and implemented to develop energy systems	AP
CO3	Identify the urgency of energy solutions	U
CO4	Understand the importance of energy storage techniques	U
CO5	Understand the role of nanotechnology in improving the efficiency in energy usage	U

Course Contents:

MODULE 1: SOLAR ENERGY TECHNOLOGY 15 Hours
Electromagnetic spectrum – Availability of solar radiation – Photovoltaic devices – Dye sensitized solar cells – Silicon technology for solar cells – First generation, second generation and third generation solar cells – Photo electrochemical cells for hydrogen production.

MODULE 2: NANOTECHNOLOGY IN RENEWABLE ENERGY SYSTEMS 15 Hours
Energy challenges – Development and implementation of renewable energy technologies – Nano technology enabled renewable energy technologies – Energy transport, conversion and storage – Nano, micro and meso scale phenomena and devices. Energy Sector Products using Nano materials: Light emitting diodes – Batteries – Catalytic reactors – Capacitors – Super capacitors – Microfluidic systems – Nano engines – Biogas – Biodiesel.

MODULE 3: FUEL CELL AND HYDROGEN STORAGE TECHNOLOGY 15 Hours
Fuel cell technologies – Integration and performance for micro – Fuel cell systems – Thin film and micro fabrication methods – Design methodologies – Micro-fuel cell power sources. **Hydrogen Storage Technology:** Hydrogen storage methods – Metal hydrides – Hydrogen storage capacity – Hydrogen reaction kinetics – Carbon-free cycle – Gravimetric and volumetric storage capacities – Hydriding /dehydriding kinetics – High enthalpy of formation – Thermal managementduringthehydridingreaction–Distinctivechemicalandphysicalproperties– Multiple catalytic effects – Degradation of the sorption properties – Hydride storage materials for automotive applications.

Total Hours:	**45**

Text Books:

1. Shatwell. R.A, “Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures - in Fuel cell technology handbook”, CRC Press,2003.
2. Hoogers.G, “Fuel cell technology handbook”, CRC Press,2003.

Reference Books:

1. Twidell. J, Weir. T, “Renewable Energy Resources”, E & F N Spon Ltd, 2nd Edition 1986.
2. Leon F, “Renewable Energy in Power Systems”, Wiley,2008.
3. Kreith.J.F, Solar Energy Handbook:, Mc Graw Hill,1981.
4. Vielstich L, “Handbook of fuel cells: Fuel cell technology and applications”, CRC Press, 2003.
5. Anatoli Korkin, David J, “Nano scale Applications for Information and Energy Systems”, Springer, 2013.
6. Darren P. Broom, “Hydrogen Storage materials: The characterization of their properties”, Springer, 2011.

Web References:

1	https://nptel.ac.in/courses/118104008/25
2	https://nptel.ac.in/courses/112106222/

Online Resources:

1	https://www.coursera.org/learn/nanotechnology
2	https://www.betteru.in/course/energy-nanotechnology-online-course-certificate/
3	https://ocw.mit.edu/courses/mechanical-engineering/2-57-nano-to-macro-transport-processes-spring-2012/video-lectures/lecture-1-intro-to-nanotechnology-nano scale-transport-phenomena/

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	2	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	2	3	3	3
CO5	3	2	2	3	3	3

25PPSE15	HIGH POWER CONVERTERS	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide depth knowledge about the various high step up power converters with its choice of selecting components and various control operation.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the basic power electronics converters.	**U**
CO2	Understand and analyze the second stage of power converters like CUK, SEPIC and modified SEPIC.	**AP**
CO3	Understand the isolated power converters with its mode of operation.	**U**
CO4	Analyze the non-isolated power converters with selection of suitable components.	**AP**
CO5	Understand the concept of inverters with its various control technique.	**U**

Course Contents:

MODULE 1 CONVERTERS **15 Hours**

Converters: Principle of Converters, Control of DC/DC Converters, Modes of operations: Buck, Boost, Buck Boost, Design procedure of inductance, capacitance and its mathematical formulation.

MODULE 2 CUK AND SEPIC CONVERTER **15 Hours**

CUK and SEPIC Converter: Principle of CUK and SEPIC Converter, Design procedure of CUK and SEPIC Converters: Duty Cycle, inductance and capacitance, Modes of operation and Explanation of Modified SEPIC Converter. **Modes of operation:** Pushpull, Flyback, and Luo, Comparison between merits and demerits of advanced converters.

MODULE 3 PRINCIPLE OF OPERATION OF CONVERTERS AND INVERTERS **15 Hours**

Principle of operation of Converters: Zeta and Boost Interleaved Converter, Design of Duty cycle, selecting of active and passive components for Zeta Converter. **Principle of operation of Inverters:** Single phase Bridge Inverters, Three Phase inverters (120 degree conduction and 180 degree conduction), Voltage Control of Single Phase Inverters: Single Pulse Width modulation, Multiple PWM, SPWM, and Modified SPWM.

Total Hours:	**45**

Text Books:

1. 1. Muhammad H. Rashid, “Power Electronics Circuits, Devices and Applications”, Third Edition, Prentice Hall of India, Pvt. Ltd., 2007.
2. 2. Daniel W. Hart, “Power Electronics”, Tata Mc Graw Hill Publication, 2011.

Reference Books:

1. Jeff Falin, “Designing DC/DC Converters based on Zeta topology”, Texas Instruments, 2010.
2. M D Singh, K B Khanchandani, “Power Electronics”, Tata Mc Graw Hill Publication, 2008, 3rd edition.
3. Alok Jain, “Power Electronics and its Applications”, Penram International Publication, 2004, 2nd edition.

Web References:

1	https://nptel.ac.in/courses/108103009/16
2	https://nptel.ac.in/courses/108103009/9

Online Resources:

1	https://www.coursera.org/learn/power-electronics
2	https://www.coursera.org/specializations/power-electronics

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	**2**	**3**	**4**	**1**	**2**
CO1	2	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE16	ARTIFICIAL INTELLIGENT TECHNIQUES	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	: Nil	

Course Objectives:

1. To provide depth knowledge in AI techniques such as Neural Networks, Fuzzy Logic and Genetic algorithm system
2. To learn the application of AI techniques in power systems Engineering.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the various methods of Artificial Intelligence Techniques	**U**
CO2	Analyse the models and architecture of Artificial Neural Networks	**AP**
CO3	Apply the concepts of fuzzy logic model and its controllers in Non Linear systems	**AP**
CO4	Understand the concept of genetic algorithm and study about various optimization techniques	**U**
CO5	Understand the various applications of AI techniques used in Power System Engineering	**U**

Course Contents:

Module 1: Introduction to AI techniques **12 Hours**
Introduction to artificial intelligence systems– Humans and Computers – Knowledge representation – Learning process – Learning tasks – Methods of AI techniques.

Module 2: Artificial Neural Networks and Fuzzy Logic **18 Hours**
Neural Network: Organization of the Brain – Biological Neuron – Biological and Artificial neuron Models, MC Culloch- pitts neuron model, Activation functions, Learning rules, neural network architectures- Single-layer feed-forward, Multi-layer feed- forward network, Back propagation algorithm– Radial-basis function networks- Recurrent networks (Hopfield networks). Fuzzy Logic: Introduction to classical sets – properties – Operations and relations – Fuzzy sets – Membership – Uncertainty – Operations – Properties – Fuzzy relations – Cardinalities – Membership functions. Fuzzification – Membership value assignment – Development of rule base and Decision Making System – Defuzzification To Crisp Sets – Defuzzification Methods

Module 3 Genetic Algorithm and Application of AI techniques **15 Hours**
Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Ant-colony search and Particle Swarm Optimization. **Application of AI techniques :**Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Reactive power control

Total Hours:	**45**

Text Books:	
1. S.N. Sivanandam and S.N. Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2nd edition 2011. 2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.	
Reference Books:	
1. S. Rajasekaran and G.A. Vijayalakshmi Pai ,”Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications”, PHI Publication. 2. Laurene V. Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education,2008. 3. David E. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009. 4. George J. Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Prentice Hall, 1st Edition,1995 5. Chennakesava R. Alavala, “Fuzzy Logic and Neural Networks- Basic Concepts and applications”, New Age International Publishers, 1st edition2008.	
Web References:	
1	https://nptel.ac.in/courses/106106126
2	https://nptel.ac.in/courses/106105077
Online Resources:	
1	https://www.coursera.org/learn/neural-networks
2	https://www.coursera.org/learn/neural-networks-deep-learning
3	https://www.coursera.org/learn/rengong-zhineng
4	https://www.coursera.org/learn/ai

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	2	3	4	1	2
CO1	3	2	3	3	2	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	3	2	3

25PPSE17	MICRO ELECTRO MECHANICAL SYSTEM	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	: Nil	

Course Objectives:

1. To get familiar with overview of MEMS and various fabrication techniques.
2. To enable the students in design, analysis and fabrication of MEMS based devices.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Choose suitable material for various micro system applications.	U
2	Acquire skills in detail the fundamental micromachining processes such as lithography, surface and bulk micromachining	U
3	Understand the working principle of MEMS based sensors and actuators.	U
4	Develop an understanding of micro scale physics for use in designing MEMS applications	AP
5	Apply MEMS for various applications	AP

Course Contents:

Module 1: Introduction **12 Hours**

Introduction to Microsystems, scaling effects; Smart materials and systems - an overview of micro sensors, micro actuators, Microsystems and smart systems with examples, Applications of MEMS devices in IoT.

Module 2: Fabrication Techniques **15 Hours**

Structure of silicon and other materials, Silicon wafer processing; Thin-film deposition, Lithography, wet etching and dry etching, Bulk micromachining and Surface micromachining, Wafer-bonding; LIGA and other molding techniques, Soft lithography and polymer processing, Thick-film processing; Low temperature co-fired ceramic processing, Smart material processing.

Module 3: Sensors and Actuators **18 Hours**

Different types of actuation and sensing methods: Electrostatic sensing and actuation-parallel plate capacitor – Application-Inertial, pressure and tactile sensor, parallel plate actuator- comb drive. Thermal sensing and Actuations-thermal sensors-Actuators- Applications- Inertial, Flow and Infrared sensors. Piezo resistive sensors- piezo resistive sensor material- stress in flexural cantilever and membrane-Application-Inertial, pressure, flow and tactile sensor. Piezoelectric sensing and actuation- piezoelectric material properties-quartz- PZT-PVDF –ZnO- Application-Inertial, Acoustic, tactile, flow-surface elastic waves Magnetic actuation- Micro magnetic actuation principle- deposition of magnetic materials-Design and fabrication of magnetic coil. Signal conditioning for microsystem devices, Vibration control of a beam, pressure sensor, Gyroscope, Accelerometer, pressure sensor design.

Total Hours:	**45**

Text Books:

1. Tai-Ran Hsu, "MEMS and Microsystems: Design, Manufacture, and Nano scale Engineering", John Wiley & Sons, Second revised edition,2008.
2. G. K. Anantha suresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, "Micro and Smart Systems", Wiley,2012.

Reference Books:

1. Marc J. Madou, "Fundamentals of Micro fabrication: The Science of Miniaturization", CRC Press, Second Edition, 2002.
2. Mohamed Gad-el-Hak," The MEMS Handbook", CRC press, Second edition,2005.
3. Julian w. Gardner, Vijay K. Varadan and Osama O. Awadelkarim, "Micro Sensors MEMS and Smart Devices", Wiley,2001.

Web References:

1	https://nptel.ac.in/courses/117105082/
2	https://nptel.ac.in/courses/112108092/

Online Resources:

1	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-777j- design-and-fabrication-of-microelectromechanical-devices-spring-2007/lecture- notes/
2	https://onlinecourses.nptel.ac.in/noc18_ee36/course

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	**2**	**3**	**4**	**1**	**2**
CO1	2	2	3	3	2	2
CO2	2	2	3	3	2	2
CO3	2	2	3	3	2	2
CO4	2	2	3	3	2	2
CO5	2	2	3	3	2	2

25PPSE18	NANO ELECTRONICS AND NANO PHOTONICS	3/0/0/3
Nature of the Course	: Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To provide the fundamental principles of nano electronics with the present research front in applications
2. To impart the knowledge of plasmonics and near field optics

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand the limitations of silicon electronics and progress of nano electronics	U
2	Emphasize the importance of electronic property of materials in mesoscopic level	AP
3	Understand the nanophotonic fabrication techniques	U
4	Understand the various aspects of biophotonics	U
5	Choose the materials based on their characteristics	AP

Course Contents:

Module 1: Evolution of Nano electronics **12 Hours**
Moore's Law – Silicon Electronics - Limitations - Discussion of the International Technology Roadmap characteristics: Need for new concepts in electronics – Silicon MOS Transistor from Micro to Nano – Future Opportunities – Nano computing. –

Module 2: Molecular Electronics and Nanophotonic Fabrication **15 Hours**
Molecular Electronics :Introduction to molectronics - An atomistic view of electrical resistance - Schrodinger equation – Self - consistent field – Bandstructure - Level broadening - Coherent transport - Non-coherent transport in molecular electronics devices – Molecular Devices – Logic Switches Nanophotonic Fabrication: Adiabatic nanofabrication – Nonadiabatic nanofabrications: Self assembling method via optical near field interactions – Regulating the size and position of nanoparticles using size dependent resonance – Size controlled, position controlled and separation controlled alignment of nanoparticles.

Module 3: Nanobiophotonics and Materials Characterization **18 Hours**
Nanobiophotonics :The cell, scale and constituents – Origin and optical contrast mechanisms – Classical contrast mechanisms: bright field, dark field, phase contrast and interferrometric contrast – Fluorescence contrast mechanism – Nonlinear microscopy based on second harmonic generation and coherent antistokes Raman scattering – Reduction of the observation volume – Far field methods, 4Pi microscopy, microscopy on a mirror and stimulated emission depletion. Materials Characterization: X-ray diffraction, Neutron diffraction and Electron diffraction– X- ray fluorescence spectroscopy–Fourier transform Infrared spectroscopy(FTIR)– Ultraviolet and visible spectroscopy (UV-Vis) – Thermogravimetric Analysis (TGA) – Differential Thermal Analysis (DTA) – Differential Scanning Calorimetry (DSC).

Total Hours:	**45**

Text Books:

1. George W. Hanson, "Fundamentals of Nanoelectronics", Prentice Hall,2007.
2. Kar I Goser et.al, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum devices", Springer,2005.
3. OhtsuM,K., Kobayashi,T.Kawazoe and T.Yatsui, "Principals of Nanophotonics (Optics and Optoelectronics)",CRC press,2003.
4. Prasad P.N., "Introduction to Biophotonics", John Wiley and Sons, 2003.
5. Thiruvadigal,J.D., Ponnusamy,S..Sudha.D. and KrishnamohanM.,"Materials Sciences", Vibrant Publication, Chennai,2013.

Reference Books:

1. Mitin V., V. Kochelap, and M. Stroscio, "Introduction to", Cambridge University Press, 2008.
2. Michael C. Petty, "Molecular Electronics: From Principles to Practice", John Wiley & Sons, Ltd, 2007.
3. Masuhara H., SKawata and F Tokunga, "Nano Biophotonics", Elsevier Science,2007.
4. BEA Saleh and AC Teich, "Fundamentals of Photonics", John Wiley and Sons,1993.
5. SeverialDumitriu, "Polymeric Biomaterials" Marcel Dekker Inc, CRC Press, Canada 2001.
6. Cao G., "Nanostructures and Nanomaterials: Synthesis, Properties and Applications", Imperial College Press,2004.

Web References:

1	https://nptel.ac.in/courses/117108047/
2	https://nptel.ac.in/courses/118104008/

Online Resources:

1	https://www.coursera.org/learn/nanotechnology1
2	https://www.edx.org/course/fundamentals-nanoelectronics-basic-purduex-nano520x

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	**2**	**3**	**4**	**1**	**2**
CO1	2	2	3	3	2	2
CO2	2	2	3	3	2	2
CO3	2	2	3	3	2	2
CO4	2	2	3	3	2	2
CO5	2	2	3	3	2	2

25PPSE19	SCADA SYSTEM AND APPLICATIONS	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To provides an introductory course material for power system automation and recent advances in technological aspects of computers and communications in networking.
2. To impart knowledge on the architecture and working of SCADA system

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand the design and implementation of a SCADA system	U
CO2	Summarize on SCADA architecture, various advantages and disadvantages of each system and single unified standard architecture IEC 61850	U
CO3	Acquire knowledge about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.	U
CO4	Acquire knowledge about SCADA communication, various industrial communication technologies, open standard communication protocols	U
CO5	Understand about SCADA applications in transmission, distribution sector and industries etc	U

Course Contents:

MODULE 1: INTRODUCTION **15 Hours**
Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries.

MODULE 2 : SCADA COMPONENTS AND ARCHITECTURE **15 Hours**
SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems. SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850.

MODULE 3 : SCADA COMMUNICATION AND APPLICATIONS **15 Hours**
SCADA communication: various industrial communication technologies -wired and wireless methods and fiber optics. open standard communication protocols. SCADA Applications: Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises.

Total Hours:	**45**

Text Books:	
1.	Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of AmericaPublications,USA,2004
2.	Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford,UK,2004
3.	William T. Shaw, Cybersecurity for SCADA systems, PennWell Books,2006
Reference Books:	
1.	David Bailey, Edwin Wright, Practical SCADA for industry, Newnes,2003
2.	Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric power, PennWell1999
Web References:	
1	https://nptel.ac.in/courses/108106022/
Online Resources:	
1	https://www.eit.edu.au/cms/courses/industrial-automation-instrumentation- process-control/professional-certificate/in-programmable-logic-controllers-plcs- scada-systems

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE20	POWER SYSTEM TRANSIENTS	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:High Voltage Engineering, HVDC Transmission	

Course Objectives:

1. To provide knowledge of origin of surges and its protective measures, insulation coordination
2. To learn the impact of surges in system components

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand electrical transients in power systems and its computation.	[U]
2	Understand the concepts of traveling waves and propagation Model transmission lines as distributed parameter systems.	[U]
3	Describe the phenomena of lightning and switching surges	[AP]
4	Discuss issues related to insulation coordination, grounding and limiting of surge effects	[AP]
5	Analyze the effects of surges in the windings of transformer and rotating machines.	[AP]

Course Contents:

Module 1: Introduction **15 Hours**

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Traveling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave. Principle of digital computation – Modal analysis, Z transforms, Computation using EMTP – Simulation of switches and non-linear elements.

Module 2 Surges and its impact on system components **15 Hours**

Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – surges on an integrated system – switching – harmonics -Very Fast Transient Overvoltage (VFTO).Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition – Rotating machine – Surge in generator and motor

Module 3 Insulation Coordination **15 Hours**

Principles of insulation co-ordination –recent advancements in insulation coordination - insulation level, statistical approach, co-ordination between insulation and protection level –over voltage protective devices – lightning arresters, substation earthing.

Total Hours:	**45**

Text Books:	

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc.,1996.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991.

Reference Books:

1. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
2. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York,1994.
3. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) New age International (P) Ltd., New Delhi,2006.

Web References:

1	https://nptel.ac.in/courses/108106026/7

Online Resources:

1	https://www.ntnu.edu/studies/courses/TET4130
2	https://www.wpi.edu/academics/online/study/power-systems-online-certificates
3	http://www.ece.mtu.edu/faculty/bamork/ee5220/index.html
4	http://eee.skpec.edu.in/wp-content/uploads/sites/6/2017/11/Power-System-Transients.pdf

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	**2**	**3**	**4**	**1**	**2**
CO1	2	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2

25PPSE21	FACTS AND CUSTOM POWER DEVICES	3/0/0/3

Nature of the Course	:Theory
Pre-requisite	:Power Electronics

Course Objectives:

1 To understand the operating principle of various kinds of FACTS devices.

2 To impart knowledge on significance and practical application of FACTS.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.	[U]
2	Develop analytical modelling skills needed for modelling and analysis of such Static VAR systems with a view towards Control Design.	[AP]
3	Acquire knowledge about the fundamental principles of Unified Power Flow Conditioner and Interline Power Flow Conditioner in Power Systems.	[AP]
4	Understand various UPFC Systems, Converters used in them and their control.	[U]
5	Develop analytical modeling skills needed for modeling and analysis of UPFC systems with a view towards Control Design	[U]

Course Contents:

Module 1 Introduction **15 Hours**
Steady-state and dynamic problems in AC systems –Power flow control - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt and series compensation – Reactive power compensation–shunt and series compensation principles VAR Compensators

Module 2 Types of FACTS devices **15 Hours**
Static shunt compensators: SVC and STATCOM -Static series compensation: TSSC, SSSC - TCVR and TCPAR- Operation and Control - GCSC,TSSC, TCSC and Static synchronous series compensators and their control – Unified Power Flow Controller:

Module 3 FACTS Controllers **15 Hours**
Modelling and analysis of FACTS Controllers – simulation of FACTS controllers -Power quality problems in distribution systems, mitigation of harmonics, passive filters, active filtering –shunt , series and hybrid and their control - power line conditioners- IEEE standards on power quality.

Total Hours:	**45**

Text Books:	
1. R.Mohan Mathur, Rajiv K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc. 2. Narain G. Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi- 110006 3. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, Publishers, New Delhi,2008.	
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.	
Web References:	
1	https://onlinecourses.nptel.ac.in/noc18_ee44/preview
2	https://nptel.ac.in/courses/121106007
Online Resources:	
1	https://npti.gov.in/flexible-ac-transmission-system

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PPSE22	POWER SYSTEM PLANNING AND RELIABILITY	3/0/0/3
Nature of the Course	: Analytical	
Pre-requisite	: 23PPS102 - Restructured Power Systems	

Course Objectives:

1. To teach the concepts of load forecasting, short term and long term planning and methodology of reactive power planning

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Summarize the trend of power consumption by end users.	U
CO2	Understand the Concepts efficient short term and long term planning of power systems.	U
CO3	Understand the control techniques to meet the constraints of reactive power consumption.	U
CO4	Explain the reliable operation of Power system under various circumstances.	U
CO5	Understand the various process involved in the different load flow techniques	U

Course Contents:

Module 1 :Introduction **15 Hours**
Objectives of forecasting - Load growth patterns and their importance in planning – Load forecasting Based on discounted multiple regression technique - Weather sensitive load forecasting - Determination of annual forecasting - Use of AI in load forecasting.

Module 2: Power System Planning **15 Hours**

Basic concepts on expansion planning - Procedure followed for integrate transmission system planning, current practice in India - Capacitor placement problem in transmission system and radial distributions system. Design of primary and secondary systems - Distribution system protection and coordination of protective devices.

Module 3: Reliability Analysis **15 Hours**
Probabilistic generation and load models - Determination of LOLP and expected value of demand not served – Determination of reliability of isolated and interconnected generation systems. Deterministic contingency analysis - Probabilistic load flow - Fuzzy load flow probabilistic transmission system reliability analysis - Determination of reliability indices like LOLP and expected value of demand not served.

Total Hours: 45

Text Books:

1.	Sullivan R.L., “Power System Planning”, McGraw Hill.Inc., US 1997.
2.	Roy Billinton and Allan Ronald, “Power System Reliability” Gardon& Breach, Newyork, 1970.

Reference Books:	
1	TuranGonen, “Electric Power Distribution System Engineering”, Second Edition, CRC press, 2007.
2	Proceeding of work shop on “Energy systems planning & manufacturing”, CI.
Web References:	
1	https://nptel.ac.in/courses/108104052/12
2	https://nptel.ac.in/courses/108101005/
Online Resources:	
1	https://www.courses.com/electrical-engineering
2	https://www.coursera.org

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2

25PPSE23	ENERGY MANAGEMENT AND AUDITING	3/0/0/3
Nature of the Course	:Theory and Analytical	
Pre-requisite	:Nil	

Course Objectives:

1. To comprehend the energy scenario and the action plan for energy management.
2. To facilitate the energy audit and the energy saving concept in the electrical system
3. To identify and assess the energy conservation/saving opportunities in different electrical systems

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Explain the fundamental concepts of different forms of energy and assess the energy scenario at the national or international level	**U**
CO2	Interpret energy conservation policies in India.	**U**
CO3	Summarize the needs and approach of energy audit and management with applications	**U**
CO4	Interpret the impact of power factor improvement, load management and maximum demand control on energy efficiency in electrical systems	**U**
CO5	Enumerate the energy-efficient technologies and their potential for energy savings in electrical systems	**U**

Course Contents:

Module 1: ENERGY CONSERVATION AND RELATED POLICIES 15 Hours

Basics of energy and its various forms, electricity tariff, load management, power factor improvement, selection & location of capacitors, performance assessment of PF capacitors, thermal basics- fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer - energy action plan, energy conservation act 2001, electricity act 2003 - National Action Plan on Climate Change (NAPCC),ISO 50001:2011.

Module 2: ENERGY MANAGEMENT & AUDIT 15 Hours

Energy management system, energy costs, benchmarking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit, energy management (audit) approach, energy audit instruments, material and energy balance - facility as an energy system, process flow in energy audit. Application: Pumps: Types, system characteristics, factors affecting pump performance, efficient pumping system operations.

Module 3: ENERGY EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 15 Hours

Electrical system, electrical load management and maximum demand control, distribution and

transformer losses - electric motors- types, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy-saving opportunities, star-labelled energy, efficient motors, maximum controllers, automatic power factor controllers, energy-efficient motors, soft starters with energy saver, variable speed drive application.	
Total Hours:	**45**

Text Books:

1. Stephan A. Roosa, Steve Doty, Wayne C. Turner “Energy Management Handbook”, Ninth Edition, Taylor & Francis group, 2020.
2. Guide to Energy Management, Barney. L, Capehart, Wayne C. Turner, William J. Kenedy, eighth Edition, Taylor & Francis group, 2020.

Reference Books:

1. Moncef Krarti, “Energy Audit of Building Systems: An Engineering Approach”, Third Edition, CRC Press,2020.
2. Albert Thumann, Terry Niehus, William Younger, " Handbook of Energy Audits” The Fairmont Press, Inc, 2013.

Web References:

1 https://beeindia.gov.in
2 https://ecoenergies.co.in/energy-audit/
3 https://onlinecourses.swayam2.ac.in/nou23_es05/preview

Course Outcomes (CO)	Programme Outcomes (PO)				Programme Specific Outcomes (PSO)	
	1	**2**	**3**	**4**	**1**	**2**
CO1	3			3	1	2
CO2	3			3	1	2
CO3	3	2	2	3	1	2
CO4	3	2	2	3	1	2
CO5	3	2	2	3	1	2

25PPSO01	WASTE TO ENERGY	3/0/0/3
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

1. To impart knowledge on the various processes involved in the conversion of waste mass to useful energy.
2. To Provide insights on the various sources of waste generation is analysed with a focus on its potential for energy production

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Interpret the fundamental idea of energy from waste and its classification as fuel	[U]
2	Understand the process of pyrolysis , its yield and application	[U]
3	Illustrate the process of gasification and its design classification	[AP]
4	Understand the concept of Biomass Combustion , its constructional types and operation	[U]
5	Summarize the Biogas properties , classification and its application	[U]

Course Contents:

Module -1 Introduction **10 Hours**

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Module -2 Biomass Gasification and Combustion **17 Hours**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifiers burner arrangement for thermal heating – Gasifiers engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifiers operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Module – 3 Biogas **18 Hours**

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion-anaerobicdigestion-TypesofbiogasPlants–Applications-Alcoholproductionfrom biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Total Hours:	**45**

Text Books:
1. Efstratios N. Kalogirou, Waste-to-Energy Technologies and Global Applications, CRC Press, 1st Edition,2017. 2. Paul Breeze, Energy from Waste, Academic Press, 1st Edition,2017.
Reference Books:
1. Desai, Ashok V., Non Conventional Energy, Wiley Eastern Ltd.,1990. 2. Khandelwal, K. C. and Mahdi, S. S., Biogas Technology - A Practical Hand Book, Vol. I & II, Tata McGraw Hill Publishing Co. Ltd.,1983. 3. Challal, D. S., Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd.,1991. 4. C. Y. WereKo- Brobby and E. B. Hagan, Biomass Conversion and Technology, John Wiley & Sons,1996.

Web References:	
1	https://nptel.ac.in/courses/103107125/8
Online Resources:	
1	https://www.studentenergy.org/topics/waste-to-energy
2	https://www.eia.gov/energyexplained/?page=biomass_waste_to_energy
3	http://www.wrfound.org.uk/articles/waste-to-energy.html

Course Outcomes (CO)	**Programme Outcomes (PO)**				**Programme Specific Outcomes (PSO)**	
	1	**2**	**3**	**4**	**1**	**2**
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

25PMC001	RESEARCH METHODOLOGY AND IPR	2/0/0/0
Nature of the Course	: Theory	
Pre-requisite	: Nil	

Course Objectives:

To cultivate the students to plan, implement and monitor systematic qualitative research studies along with Intellectual property rights

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	Understand research problem formulation.	U
CO2	Analyze research related information and follow research ethics	AP
CO3	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.	U
CO4	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	U
CO5	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social.	U

Course Contents:

MODULE 1

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations, Effective literature studies approaches, analysis, plagiarism and Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

MODULE 2

Nature of Intellectual Property: Patents, Designs, Trade and Copyright .Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT**.**

MODULE 3

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs		
	Total Hours	**30 hours**
Reference Books:		

1.	Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2.	Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction
3.	Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4.	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
5.	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
6.	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

25PAD001	ENGLISH FOR RESEARCH PAPER WRITING	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide knowledge about writing skills, level of readability and provide information about skills of writing research paper.

Course Outcomes:
Upon completion of the course, students shall have ability to

CO1	An evaluation of different types of evidence.	U
CO2	Synthesis of source material with own writing.	AP
CO3	Prepare an original and clearly supported thesis	AP
CO4	Prepare in-text citations and works-cited page.	AP

Course Contents:

Module 1: PLANNING AND PREPARATION
Word Order, Breaking up long sentences, Structuring and Paragraphs Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Module 2:REVIEW OF THE LITERATURE
Methods, Results, Discussion, Conclusions The Final Check. key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature

Module 3:KEY SKILLS NEEDED
skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions
useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

Total Hours: 30

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) 2011.
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

25PAD002	DISASTER MANAGEMENT	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide knowledge about key concepts in disaster risk reduction, humanitarian response policy and practical from multiple perspectives.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understanding of standards of humanitarian response and practical relevance	[U]
2	Understand the strengths and weaknesses of disaster management approaches	[U]
3	Understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.	[U]
4	Understand the strengths and weaknesses of disaster management approaches	[U]
5	Analyse the planning and programming in different countries, particularly their home country	[AP]

Course Contents:

Module 1: Introduction Disasters And Hazards
Disaster: Definition, Factors And Significance; Difference Between Hazard and Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Module 2: Disaster Prone Areas In India
Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics Disaster Preparedness And Management: Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Module 3: Risk Assessment and Disaster Mitigation
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival. Emerging Trends in Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster In India.

Total Hours: 30

Reference Books:

1. R.Nishith,SinghAK,"DisasterManagementinIndia:Perspectives,issuesandstrategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.

25PAD003	VALUE EDUCATION	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide awareness on education, self development skills and ability to improve the characters as well as behaviour of students.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand the Knowledge of self-development	[U]
2	Understand the importance of Human values	[U]
3	Develop the the overall personality.	[AP]

Course Contents:

Values and self-development
Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements. **Importance of cultivation of values**: sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature , Discipline.

Personality and Behaviour Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking. Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature.

Character and Competence –Holy books vs Blind faith-Self-management and Good health, Science of reincarnation, Equality, Nonviolence ,Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

Total Hours:	**30**

Reference Books:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

25PAD004	CONSTITUTION OF INDIA	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide awareness on premises informing the twin themes of liberty and freedom from a civil rights perspective and to address growth of Indian opinion regarding modern Indian intellectualsconstitutionalroleandentitlementtocivilandeconomicrightsaswellasaddress the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.	[U]
2	Analyse the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.	[AP]
3	Analyse the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.	[AP]
4	Understand the passage of the Hindu Code Bill of 1956.	[U]

Course Contents:

History of Making of the Indian Constitution
History**,** Drafting Committee, (Composition& Working), **Philosophy of the Indian Constitution:** Preamble**,** Salient Features. Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion**,** Cultural and Educational Rights**,** Right to Constitutional Remedies, Directive Principles of State Policy**,** Fundamental Duties.

Organs of Governance and Local Administration
Parliament**,** Composition**,** Qualifications and Disqualifications**,** Powers and Functions **,**Executive President**,** Governor , Council of Ministers**,** Judiciary, Appointment and Transfer of Judges, Qualifications**,** Powers and Functions **Local Administration:** District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat.**,** Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Election Commission
Election Commission: Role and Functioning Chief Election Commissioner and Election Commissioners.-State Election Commission: Role and Functioning- Institute and Bodies for the welfare of SC/ST/OBC and women.

Total Hours: 30

Reference Books:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition,2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.

25PAD005	PEDAGOGY STUDIES	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide information on Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers as well as Identify critical evidence gaps to guide the development

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Understand the pedagogical practices are being used by teachers in formal and informal classrooms in developing countries	[U]
2	Analyse the evidence on the effectiveness of these pedagogical practices	[AP]
3	Understand the teacher education (curriculum and practicum) and the school curriculum as well as guidance materials best support effective pedagogy	[U]

Course Contents:

Introduction and Methodology:
Aims and rationale, Policy background, Conceptual framework and terminology**,** Theories of learning, Curriculum, Teacher education.**,** Conceptual framework, Research questions**,** Overview of methodology and Searching. Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education**.**

Evidence on the effectiveness of pedagogical practices
Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?-Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Professional development:
Alignment with classroom practices and follow-up support Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes. **Research gaps and future directions**: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Total Hours:	**30**

Reference Books:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count, International Journal Educational Development, 33 (3):272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

25PAD006	STRESS MANAGEMENT BY YOGA	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To provide information on significance of health of body and mind and provide information about over come stress.

Course Outcomes:
Upon completion of the course, students shall have ability to

1	Develop healthy mind in a healthy body thus improving social health	[AP]
2	Develop efficiency of student	[AP]

Course Contents:

Definitions of Eight parts of yoga. (Ashtanga)- Yam and Niyam. Do`s and Don’t’s in life.-Ahinsa, satya, astheya, bramhacharya and aparigraha - Shaucha, santosh, tapa, swadhyay, ishwarpranidhan Asan and Pranayam; Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

Total Hours:	**30**

Reference Books:

1. ‘Yogic Asanas for Group Tarining- Part-I” : Janardan Swami Yogabhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

25PAD007	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	2/0/0/0
Nature of the Course	:Theory	
Pre-requisite	:Nil	

Course Objectives:

To learn to achieve the highest goal happily, To become a person with stable mind, pleasing personality and determination.

Course Outcomes:

Upon completion of the course, students shall have ability to

1	Understand Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life	[U]
2	Analyse the Geeta which lead the nation and mankind to peace and prosperity	[AP]
3	Understand the Neetishatakam which help in developing versatile personality of students.	[U]

Course Contents:

Neetisatakam: Holisticdevelopmentofpersonality,Verses-19,20,21,22(wisdom),Verses-29, 31, 32 (pride & heroism), Verses- 26, 28, 63, 65 (virtue),Verses- 52, 53, 59 (dont's),Verses-71, 73, 75, 78 (do's)

Approach to day to day work and duties: Shrimad Bhagwad Geeta: Chapter 2- Verses 41, 47, 48. Chapter 3- Verses 13, 21, 27, 35, Chapter 6- Verses 5, 13, 17, 23, 35, Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge: Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68**,** Chapter 12- Verses 13, 14, 15, 16,17, 18**,** Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses17,Chapter3-Verses36,37,42,Chapter4-Verses18,38,39**,**Chapter18–Verses 37, 38, 63

Total Hours: 30

Reference Books:

1. Srimad "Bhagavad Gita" by Swami Swarupan and a Advaita Ashram (Publication Department) , Kolkata.
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P. Gopinath,
3. Rashtriya Sanskrit Sansthanam, New Delhi