DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ANNA UNIVERSITY, CHENNAI – 25

VISION OF THE DEPARTMENT

The vision of Anna University is to be a world class institution by producing professionals with high technical knowledge, professional skills and ethical values, and remain as a preferred partner to the industry and community for their economic and social development through excellence in teaching, research and consultancy. Anna University shall be recognized as a point of reference, a catalyst, a facilitator, a trend setter and a leader in technical education.

MISSION OF THE DEPARTMENT

To produce full fledged Electrical and Electronics Engineers to cater to the needs of the modern industries and be useful for building the nation.

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UNIVERSITY DEPARTMENTS
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM

M.E. HIGH VOLTAGE ENGINEERING

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To prepare the students for successful career in high voltage equipment manufacturers, electrical power industry , research and teaching institutions
II. To provide strong foundation in Insulation technology and in engineering necessary to formulate, solve and analyse electromagnetic field problems
III. To develop the ability to estimate and analyse overvoltages in power system
IV. To develop the ability to generate , measure the high voltages and to test High Voltage power apparatus
V. To provide strong foundation in the physics of insulating materials and develop the ability to design High Voltage power apparatus
VI. To promote student awareness for the lifelong learning and introduce them to the professional ethics

2. PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the graduate would have attained the

PO#	Graduate Attribute	Programme Outcome
1.	Engineering Knowledge	Apply knowledge of basic science and engineering science in the design and testing of high voltage system and equipment
2.	Problem Analysis	Formulate, simulate and design of power system and equipment under various types of overvoltages.
3.	Design / Development of Solutions	Optimal design of insulation scheme for power system and apparatus
4.	Conduct investigations of complex problems	Design and conduct experiments towards research in the areas of material characterization, insulation design, applications of high electric fields in interdisciplinary areas
5.	Model tool usage	Model and analyze power system for transient analysis and insulation design using computational softwares
6.	The Engineer and Society	To design power equipment and conduct Dielectric tests as per national and international test standards
7	Environment and Sustainability	Design the system with environment consciousness and sustainable development based on electric and magnetic field distributions
8.	Ethics	To accept responsibilities in making engineering decisions consistent with the safety, health and welfare of public and to Interact with industry, business and society in a professional and ethical manner
9.	Individual and team work	Function in core and multi-disciplinary teams
10.	Communication	Proficiency in oral and written Communication to present technical subjects

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11.	Project Management and Finance	Implement cost effective and improved high voltage systems
12.	Life-long learning	Continue professional development and learning as a life-long activity.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

By the completion of High Voltage Engineering program the student will have the following specific outcomes

1. Foundation of High Voltage Engineering: Ability to understand the fundamental physics of insulating materials and to acquire and apply knowledge of mathematics and electromagnetic fields in High Voltage Engineering
2. Generation and measurement of High Voltage Engineering: Ability to design, analyse, simulate, generate, measure High voltages and currents and to conduct experiments towards research.
3. Insulation Design of High voltage apparatus: Ability to analyze power system for transient overvoltages and to optimally design insulation scheme for High Voltage power apparatus using computational softwares.
4. Testing of High voltage apparatus: Ability to conduct Destructive and Non -Destructive tests as per national and international test standards.
5. Design and conduct experiments towards research : Ability to use knowledge in development and characterisation of new dielectric materials , estimation and measurement of E & H fields to check design of power equipment and the exposure limits for environmental safety and application of high electric fields in interdisciplinary domains such as food preservation, cancer treatment and agriculture .

4. PEO / PO Mapping:

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓		✓	✓				✓	✓	✓	
III		✓			✓	✓	✓					
IV		✓	✓	✓	✓	✓			✓			✓
V	✓	✓	✓		✓		✓		✓	✓	✓	
VI	✓		✓	✓	✓	✓		✓	✓			✓

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			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR 1	SEM 1	High Voltage Generation and Measurement	✓	✓		✓					✓		✓	
		Insulation Technology	✓	✓	✓		✓	✓	✓					
		Electromagnetic Field Computation and Modeling	✓	✓	✓		✓		✓					
		Electrical Transients in Power System	✓	✓		✓	✓		✓					
		Program Elective I												
		Research Methodology and IPR	✓	✓			✓	✓		✓				✓
		Audit Course I (one from list of Audit Courses)												
		High Voltage Generation and Measurement Laboratory	✓	✓		✓	✓				✓			
		Electromagnetic Field Computation Laboratory	✓	✓	✓		✓		✓					
	SEM 2	High Voltage Testing Techniques	✓			✓		✓	✓	✓	✓			✓
		Insulation Design of High Voltage Power Apparatus	✓	✓	✓			✓					✓	✓
		Program Elective II												
		Program Elective III												
		Program Elective IV/ Mini Project												
		Audit Course I (one from list of Audit Courses)												

		Insulation Design Laboratory			✓		✓	✓	✓			✓	✓	✓
		Advanced High Voltage Laboratory	✓	✓	✓	✓		✓	✓			✓		✓
YEAR 2	**SEM 3**	Program Elective V Program Elective VI												
		Open Elective												
		Project Phase I	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
	SEM 4	Project Phase II	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

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M.E.HIGH VOLTAGE ENGINEERING
CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HV5101	High Voltage Generation and Measurement	PCC	3	0	0	3	3
2.	HV5102	Insulation Technology	PCC	4	0	0	4	4
3.	HV5151	Electromagnetic Field Computation and Modelling	PCC	3	0	0	3	3
4.	HV5103	Electrical Transients in Power System	PCC	3	1	0	4	4
5.		Program Elective I	PEC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I* (one from list of Audit Courses)	AC	2	0	0	2	0
PRACTICALS								
8.	HV5111	High Voltage Generation and Measurement Laboratory	PCC	0	0	4	4	2
9.	HV5112	Electromagnetic Field Computation Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**1**	**8**	**29**	**23**

*Audit Course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HV5201	High Voltage Testing Techniques	PCC	4	0	0	4	4
2.	HV5202	Insulation Design of High Voltage Power Apparatus	PCC	3	0	0	3	3
3.		Program Elective II	PEC	3	0	0	3	3
4.		Program Elective III	PEC	3	0	0	3	3
5.		Program Elective IV / Mini Project	PEC	3/0	0	0/6	3/6	3
6.		Audit Course II* (one from list of Audit Courses)	AC	2	0	0	2	0
PRACTICALS								
7.	HV5211	Insulation Design Laboratory	PCC	0	0	4	4	2
8.	HV5212	Advanced High Voltage Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**20**

*Audit Course is optional

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective V	PEC	3	0	0	3	3
2.		Program Elective VI	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	HV5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	HV5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS - 70

PROGRAM CORE COURSES (PCC)

S. No.	Course Code	Course title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	HV5101	High Voltage Generation and Measurement	3	0	0	3	1
2.	HV5102	Insulation Technology	4	0	0	4	1
3.	HV5151	Electromagnetic Field Computation and Modelling	3	0	0	3	1
4.	HV5103	Electrical Transients in Power System	3	1	0	4	1
5.	HV5111	High Voltage Generation and Measurement Laboratory	0	0	4	2	1
6.	HV5112	Electromagnetic Field Computation Laboratory	0	0	4	2	1
7.	HV5201	High Voltage Testing Techniques	4	0	0	4	2
8.	HV5202	Insulation Design of High Voltage Power Apparatus	3	0	0	3	2
9.	HV5211	Insulation Design Laboratory	0	0	4	2	2
10.	HV5212	Advanced High Voltage Laboratory	0	0	4	2	2
					Total Credits	**29**	

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PROFESSIONAL ELECTIVE COURSES (PEC)

S. No.	Code no.	Course title	Periods per week			Contact Periods	Credits
			Lecture	Tutorial	Practical		
1.	HV5001	Design of High Voltage Switchgear	3	0	0	3	3
2.	HV5002	Condition Monitoring of High Voltage Power Equipment	3	0	0	3	3
3.	HV5003	Nano Dielectrics	3	0	0	3	3
4.	HV5071	Applications of High Electric Fields	3	0	0	3	3
5.	HV5072	Design of Substations	3	0	0	3	3
6.	HV5073	Electromagnetic Interference and Compatibility	3	0	0	3	3
7.	HV5074	Pollution Performance of Power Apparatus and Systems	3	0	0	3	3
8.	HV5075	Principles of Electric Power Transmission	3	0	0	3	3
9.	HV5076	Mini Project	0	0	6	6	3
10.	CO5251	Machine Learning	3	1	0	4	4
11.	PS5151	Analysis and Computation of Electromagnetic Transients in Power Systems	3	1	0	4	4
12.	PS5251	HVDC and FACTS	3	1	0	4	4
13.	PS5075	Smart Grid	3	0	0	3	3
14.	PS5071	Application of AI Techniques to Power Systems	3	0	0	3	3
15.	PS5076	Wind Energy Conversion System	3	0	0	3	3
16.	PS5252	Restructured Power System	3	0	0	3	3
17.	PS5074	Optimization Techniques	3	0	0	3	3
18.	PS5072	Application of DSP to Power System Protection	3	0	0	3	3
19.	PW5153	Modern Power System Engineering	3	1	0	4	4
20.	PW5151	Climate Change and Energy Environment	3	0	0	3	3
21.	PW5251	Energy Management and Audit	3	1	0	4	4
22.	PW5077	Renewable Energy Technology	3	0	0	3	3
23.	PW5071	Electric Vehicles and Power Management	3	0	0	3	3
24.	PW5072	Energy Efficient Buildings	3	0	0	3	3
25.	PW5073	Energy Forecasting, Modelling and Project Management	3	0	0	3	3
26.	PW5152	Energy Conservation in Electrical Systems	3	0	0	3	3
27.	PW5252	Optimization Techniques for Energy Management	3	1	0	4	4
28.	PW5079	Waste Management and Energy Recovery Techniques	3	0	0	3	3
29.	PW5074	Energy Storage Technologies	3	0	0	3	3

30.	PE5074	Power Quality	3	0	0	3	3
31.	PE5251	Special Electrical Machines	3	0	0	3	3
32.	PE5151	Analysis of Electrical Machines	3	1	0	4	4

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL.NO	CODE NO.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	HV5311	Project Phase I	0	0	12	6	3
2	HV5411	Project Phase II	0	0	24	12	4
					Total Credits:	**21**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

SL.NO	CODE NO.	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM5151	Research Methodology and IPR	2	0	0	2	1
					Total Credits	2	

OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
		Total Credits				**0**	

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SUMMARY

M.E HIGH VOLTAGE ENGINEERING							
Sl. No.	**Subject Area**	**Credits per Semester**				**Total Credits**	**%**
		I	**II**	**III**	**IV**		
1.	PCC	18	11	0	0	**29**	**41**
2.	PEC	3	9	6	0	**18**	**26**
3.	RMC	2	0	0	0	**2**	**3**
4.	OEC	0	0	3	0	**3**	**4**
5.	EEC	0	0	6	12	**18**	**27**
6.	Non Credit / Audit Course	✓	✓	0	0	**0**	
	Total Credits	**23**	**20**	**15**	**12**	**70**	

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HV5101 HIGH VOLTAGE GENERATION AND MEASUREMENT LT P C
3 0 0 3

COURSE OBJECTIVES

- To provide strong knowledge on different types of electrical stresses on power system and equipment.
- To impart knowledge on generation of high AC and DC voltages
- To provide adequate knowledge to simulate and generate impulse voltages
- To expose the different techniques of measuring High voltages
- To provide adequate knowledge to generate impulse currents and its measurement techniques

UNIT I GENERATION OF DIRECT VOLTAGES 9

Requirements of HV generation in Laboratory, voltage stress, testing voltages, generation of direct voltages – AC to DC conversion – single phase rectifier circuits – cascade circuits – voltage multiplier circuits – Cockcroft-Walton circuit – voltage regulation – ripple factor – Electrostatic generators.

UNIT II GENERATION OF ALTERNATING VOLTAGES 9

Testing transformer – single unit testing transformer, cascaded transformer – equivalent circuit of cascaded transformer –resonant circuits – resonant transformer – voltage regulation.

UNIT III GENERATION OF IMPULSE VOLTAGES 9

Impulse voltage, general shape and definition of lightning impulses, generator circuit – Marx generator –analysis of various impulse voltage generator circuits, controlled switching – multistage impulse generator circuits – Switching impulse generator circuits – generation of non-standard impulse voltages and very fast transient voltage (VFTO)- Relevant IS and IEC Standards

UNIT IV MEASURMENT OF HIGH VOLTAGES 9

Measurement of high AC, DC Impulse voltages - Peak voltage measurements by sphere gaps – Electrostatic voltmeter – generating voltmeters and field sensors – Chubb-Fortescue method – voltage dividers, types, dynamic response and impulse voltage measurements- Relevant IS and IEC Standards

UNIT V GENERATION AND MEASUREMENT OF IMPULSE CURRENTS 9

Generation of impulse currents, measurement of high DC, AC and impulse currents – shunts, measurement using magnetic potentiometers and magnetic coupling - Fast digital transient recorders for impulse measurements

L=45: P=0, Total = 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to design, simulate and generate HVDC
CO2: Ability to design, simulate and generate HVAC
CO3: Ability to design, simulate and generate impulse voltage
CO4: Ability to design and analyze the suitable measuring circuits for HV
CO5: Ability to design the suitable generating and measuring circuits of impulse current

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓					✓		✓	
CO2	✓	✓		✓					✓		✓	
CO3	✓	✓		✓					✓		✓	
CO4	✓	✓		✓					✓		✓	
CO5	✓	✓		✓					✓		✓	

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1. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, Second edition, 2008
2. Dieter Kind, Kurt Feser, "High Voltage Test Techniques", SBA Electrical Engineering Series, New Delhi, 1999.
3. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-hill Publishing Company Ltd., Fifth edition., New Delhi, 2017.
4. Gallagher, T.J., and Permain, A., "High Voltage Measurement, Testing and Design", John Wiley Sons, New York, 1983.
5. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, RoshdyRadwan, "High Voltage Engineering Theory and Practice" Second Edition, Revised and Expanded, Marcel Dekker, Inc., New York, 2000.
6. N.H.Malik, A.A.Al_Arainy, M.I.Qureshi, "Electrical Insulation in Power Systems", marcel Dekker,Inc., New York 1988.
7. Adolf J. Schwab, "High Voltage Measurement Techniques", M.I.T Press, 1972.

HV5102 INSULATION TECHNOLOGY LT P C
4 0 0 4

COURSEOBJECTIVES:

- To gain in-depth knowledge on behavior of dielectrics under Static fields.
- To gain in-depth knowledge on behavior of dielectrics under alternating fields.
- To study the breakdown mechanism of Gaseous dielectrics.
- To study the breakdown mechanism of Liquid and Solid dielectrics.
- To enable the students to become familiar with application of dielectric materials for power equipment.

UNIT I PROPERTIES OF DIELECTRICS IN STATIC FIELDS 12

Static dielectric constant – Polarization and dielectric constant – atomic interpretation of the dielectric constant of mono-atomic gases –dependence of permittivity on various factors– internal field in solids and liquids – static dielectric constant of solids – properties of ferroelectric materials – spontaneous polarization – Piezoelectricity.

UNIT II BEHAVIOR OF DIELECTRICS IN ALTERNATING FIELDS 12

Frequency dependence of the electronic polarizability – ionic polarization as a function of frequency – complex dielectric constant of non-dipolar solids – dipolar relaxation – dielectric losses.

UNIT III BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS 12

Behaviour of gaseous dielectrics in electric fields – gaseous discharges – different ionization processes – effect of electrodes on gaseous discharge – Townsend's theory, Streamer theory – electronegative gases, gaseous discharges in non-uniform fields – alternate Green gases and mixture of gases- breakdown in vacuum insulation .

UNIT IV BREAKDOWN MECHANISMS IN SOLID AND LIQUID DIELECTRICS 12

Solid Dielectrics-Intrinsic breakdown of solid dielectrics – electromechanical breakdown-Streamer breakdown, thermal breakdown - electrochemical breakdown – tracking and treeing – thermal and electrical ageing and partial discharges - classification of solid dielectrics, composite insulation.

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Liquids dielectrics- conduction and breakdown in pure and commercial liquids, Dissolved gas analysis -Cryogenic insulation-Biodegradable oils

UNIT V LIFE ESTIMATION AND APPLICATION OF INSULATING MATERIALS **12**

Life estimation- thermal modelling- DP/Furan/DGA Results and Application of insulating materials in power equipment and recent advancements-environment friendly and recyclable insulation

TOTAL : 60 PERIODS

COURSEOUTCOMES:

CO1 Ability to understand the fundamental behavior of dielectrics in static fields.
CO2 Ability to understand the fundamental behavior of dielectrics in alternating fields.
CO3To understand the performance of gaseous dielectrics.
CO4 Ability to understand the behavior of liquid and solid dielectrics
CO5 Ability to select the suitable insulation for an electrical power equipment

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓	✓										
CO3			✓		✓	✓						
CO4			✓		✓	✓						
CO5			✓		✓	✓	✓					

REFERENCES

1. Adrinaus, J.Dekker, “Electrical Engineering Materials”, Prentice Hall of India Pvt. Ltd., New Delhi, 1979.
2. Dieter Kind and Hermann Karner, “High Voltage Insulation Technology”, 1985. (Translated from German by Y. Narayana Rao, Friedr. Vieweg&Sohn, Braunschweig,).
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005
4. Alston, L.L, “High Voltage Technology”, Oxford University Press, London, 1968 (B.S
5. Publications, First Indian Edition 2006)
6. M.S Naidu, V.Kamaraj, “High Voltage Engineering”, Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, 2004.
7. V.Y.Ushakov, “Insulation of High Voltage Equipment”, Springer ISBN.3-540-20729-5, 2004.
8. R.E.james and Q.Su,“Condition Assessment of High Voltage Insulation in Power System Equipment”, IET publications,London,U.K,2008.

HV5151 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **LT P C 3 0 0 3**

COURSEOBJECTIVES:

- To refresh the fundamentals of Electromagnetic Field Theory
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart knowledge in fundamentals of FEM
- To compute and analyze the field quantities using FEM
- To formulate, solve, analyze and optimize the design of electrical components

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UNIT I INTRODUCTION 9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9

Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES 9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance

UNIT V DESIGN APPLICATIONS 9

Design of Insulators –Magnetic actuators – Transformers – Rotating machines.

L=45: T=0, TOTAL = 45 PERIODS

COURSEOUTCOMES:

CO1 Ability to understand the field theory concepts
CO2Ability to formulate and compute Electromagnetic Fields from Maxwell's equations.
CO3 Ability to formulate FEM problems from the fundamental concepts
CO4 Ability to compute the respective field using FEM (post processing)
CO5 Ability to check and optimize the design of electrical power equipment

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3			✓		✓							
CO4					✓							
CO5			✓		✓							

REFERENCES

1. Matthew. N.O. Sadiku, S.V. Kulkarni, "Elements of Electromagnetics", Sixth Edition, Oxford University Press, Asian Edition 2015.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A.Bastos, "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983

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HV5103 **ELECTRICAL TRANSIENTS IN POWER SYSTEM** **LT P C**
3 1 0 4

COURSEOBJECTIVES:

- To gain knowledge in sources of transients like lightning, switching and temporary overvoltages.
- To model power system components and estimate the overvoltages in power system
- To analyze travelling wave phenomena against different overvoltages
- To compute transient overvoltages using Electromagnetic Transient Program (EMTP).
- To coordinate the insulation of power system and protective devices.

UNIT I LIGHTNING OVERVOLTAGES 12

Classification of over voltages- Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike, Grounding for protection against lightning – Steady state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 12

Switching transients – concept – phenomenon – system performance under switching surges- Ferranti Effect, Temporary overvoltages – load rejection – line faults – ferroresonance, VFTO

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE 12

Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multiconductor system and multivelocity waves

UNIT IV INSULATION CO-ORDINATION 12

insulation co-ordination –volt –time characteristics , Insulation strength and their selection- Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 12

Computation of transients using electromagnetic transient program-Modelling of power system components- Simple case studies - Application of simplified method: single line station, two line station, gas insulated substations, comparison with IEEE and IEC guides

L= 45: T=15, TOTAL : 60 PERIODS

COURSEOUTCOMES:

CO1: Ability to understand various sources of transients
CO2: Ability to compute possible overvoltages in power systems
CO3: Ability to predict overvoltages in power system using travelling wave theory
CO4: Ability to compute overvoltages using EMTP with multiple sources
CO5: Ability to coordinate the insulation level of the power system

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓							
CO2	✓	✓		✓	✓							
CO3	✓	✓		✓	✓							
CO4	✓	✓		✓	✓							
CO5	✓	✓		✓	✓		✓					

Attested

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REFERENCES

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.
3. Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor & Francis Group, New York, 1999.
4. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
5. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi, 2006.
6. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
7. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
8. Working Group 33/13-09 (1988), ‘Very fast transient phenomena associated with Gas Insulated System’, CIGRE, 33-13, pp. 1-20.
9. R. Ramanujam, “Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation”, I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, 2014

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

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

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

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.

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UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

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, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL HOURS: 30

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

HV5111 HIGH VOLTAGE GENERATION AND MEASUREMENT LABORATORY LT P C 0 0 4 2

COURSEOBJECTIVES:

To acquire hands on experience

- to analyze and design HVAC and HVDC
- to analyze and design impulse voltage generators
- to generate and measure HVAC and HVDC
- to generate and measure standard and non-standard impulse voltages
- to generate and measure impulse current

LIST OF EXPERIMENTS

1. Analysis and Design of high voltage DC generators using circuit simulation package
2. Analysis and Design of high voltage AC generators using circuit simulation package
3. Analysis and Design of high Impulse voltage generators using circuit simulation package
4. Generation and measurement of HVDC
5. Generation and measurement of HVAC
6. Generation and measurement of standard impulse voltages
7. Generation and measurement of non-standard impulse voltages
8. Comparison of various high voltage measurement methods

P = 60 ,TOTAL = 60 PERIODS

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COURSEOUTCOMES:

CO1: Ability to analyze and design HVAC and HVDC
CO2: Ability to analyze and design impulse voltage generators
CO3: Ability to generate and measure HVAC and HVDC
CO4: Ability to generate and measure standard and non-standard impulse voltages
CO5: Ability to generate and measure impulse current

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓								
CO2	✓	✓		✓								
CO3		✓		✓	✓				✓			
CO4		✓		✓	✓				✓			
CO5		✓		✓					✓			

HV5112

ELECTROMAGNETIC FIELD COMPUTATION LABORATORY

L T P C
0 0 4 2

COURSEOBJECTIVES:

- To compute and visualize the vector fields using computational software
- To formulate, compute and analyse basic electrostatic field configurations
- To formulate, compute and analyse basic magnetostatic field configurations
- To carryout Ac conduction analyses on Transmission lines.
- To provide knowledge in computer aided design of electrical equipment

LIST OF EXPERIMENTS

1. Graphical representation of fields: Gradient, Divergence and Curl fields
2. Electrostatics: Computation of Voltage distribution, Electric field intensity and Capacitance on simple configurations-Parallel plate capacitor and Coaxial cable
3. Magnetostatics: Computation of magnetic field intensity, Inductance and Force on Conductors, Circular ring, Solenoid and magnetic circuit with air gap
4. AC conduction analysis: Transmission line - single phase, three phase configuration
5. Eddy current analysis
6. Field computation and analysis on
   i. Cylindrical magnetic actuator
   ii. Single phase transformer
   iii. High Voltage Insulator
   iv. Rotating machines
   v. Single phase variable reactance

P = 60 ,TOTAL = 60 PERIODS

COURSEOUTCOMES:

CO1Ability to represent and understand the vector fields
CO2 Ability to compute and analyze the electrostatic field problems
CO3 Ability to compute and analyze magneto static and eddy current problems
CO4 Ability to check the design of transmission lines
CO4 Ability to check and optimize the design of electrical equipment

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓				✓							
CO2		✓	✓		✓							
CO3		✓	✓		✓							

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CO4		✓	✓		✓		✓					
CO5		✓	✓		✓							

HV5201 HIGH VOLTAGE TESTING TECHNIQUES LT P C
4 0 0 4

COURSEOBJECTIVES:
To acquire knowledge,
- on the different types of testing and measurement techniques
- on pre-testing procedures by statistical evaluation methods
- on required tests and the procedures for various high voltage power apparatus as per IS/IEC/IEEE standards.
- on Non-destructive test methods for assessing insulation characteristics
- on performing artificial pollution test and design of HV lab

UNIT I INTRODUCTION 12
Objectives of high voltage testing, classification of testing methods- self restoration and non-self-restoration systems- IS/IEC/IEEE standards and specifications, measurement techniques ,Diagnostic testing – online measurement, standard test cells

UNIT II STATISTICAL EVALUTION OF MEASURED RESULTS 12
Determination of probability values, Distribution function of a measured quantity, confidence limits of the mean values of disruptive discharges - 'Up and Down' method for determining the 50% disruptive discharge voltage, multi stress ageing, life data analysis

UNIT III TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT 12

Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers, voltage transformers, current transformers, surge arresters ,cable -testing methodology-recording of oscillograms - interpretation of test results

UNIT IV NON-DESTRUCTIVE INSULATION TEST TECHNIQUES 12

Dynamic properties of dielectrics-dielectric loss and capacitance measurement-partial discharge measurements-basic partial discharge (PD) circuit – PD currents- PD quantities -Digital PD instruments and measurements, acoustic, emission technique and UHF Techniques for PD identification, Corona and RIV measurements on line hardware

UNIT V POLLUTION TESTS AND DESIGN OF HIGH VOLTAGE LAB 12

Artificial Pollution tests- salt-fog method, solid layer method, Design of High voltage laboratory, equipment- fencing, earthing and shielding.

L=60: Total = 60 PERIODS

COURSEOUTCOMES:
CO1: Ability to select appropriate type of test for each high voltage power apparatus
CO2: Ability to do life data analysis and statistical evaluation of measured results
CO3: Ability to conduct Dielectric tests as per standards on various HV power apparatus
CO4: Ability to carry out Non-destructive tests on evaluation of insulation characteristics
CO5: Ability to execute artificial pollution test and design different types of HV lab

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2												
CO3	✓			✓		✓		✓	✓			✓
CO4				✓								
CO5	✓			✓		✓	✓	✓				✓

REFERENCES

1. Dieter Kind, Kurt Feser, “High voltage test techniques”, SBA Electrical Engineering Series, New Delhi, 1999.
2. Naidu M.S. and Kamaraju V., “High voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., Fifth Edition., New Delhi, 2017.
3. Relevant test standards.
4. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, Second edition., 2008
5. Gallagher, T.J., and Pearmain A., “High Voltage Measurements, Testing and Design”, John Willey & Sons, New York, 1983.
6. IS, IEC and IEEE standards for “Dielectric Testing of High Voltage Apparatus” W.Nelson, Applied Life Data Analysis, John Wiley and Sons, New York, 1982.
7. W.Kennedy, “Recommended Dielectric Tests and Test Procedures for Converter Transformer and Smoothing Reactors”, IEEE Transactions on Power Delivery, Vol.1, No.3, pp 161-166, 1986.
8. IEC – 60270, “HV Test technique – Partial Discharge Mechanism”, 3rd Edition December 2000.
9. M.D Judd, Liyang, Ian BB Hunter, “P.D Monitoring of Power Transformers using UHF Sensors” Vol.21, No.2, pp5-14, 2004.
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HV5202 INSULATION DESIGN OF HIGH VOLTAGE POWER APPARATUS **LT P C 3 0 0 3**

COURSEOBJECTIVES:

- To provide fundamental knowledge about the role and schemes of insulation and stress control techniques in high voltage equipment.
- To acquire knowledge on design principles of Insulators, bushings and capacitors
- To design the different insulation schemes, stress control methods and to study the transient behavior of the windings.
- To design the high voltage instrument transformers and cable joints
- To design and model the surge arrester under different operating conditions.

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UNIT I INTRODUCTION 9

Electrical field distribution and breakdown strength of insulating materials - factors affecting the breakdown strength - electric field distribution in homogenous and multi-dielectric isotropic materials- electrical field control techniques

UNIT II HV INSULATORS, BUSHINGS AND CAPACITORS 9

Basic configurations, Classification based on insulating materials and application, design principles

UNIT III POWER TRANSFORMERS 9

Insulation schemes in transformer, types of transformer winding, design of internal, main and end insulation, surge phenomena in transformer windings- stress control techniques

UNIT IV INSTRUMENT TRANSFORMERS AND CABLE JOINTS 9

Classification based on insulating materials and design of potential and current transformers, Types of cable joints and terminations-capacitive grading- non-linear resistive grading

UNIT V SURGE ARRESTER 9

Types of surge arresters - gapped and gapless - electrical characteristics – housing materials – design - pollution performance - modeling of arrestor

L = 45: T = 0, Total = 45 PERIODS

COURSEOUTCOMES:

CO1 Ability to analyze the factors influencing the performance of insulation of power equipment.
CO2Ability to design high voltage Insulators, bushing and capacitors
CO3 Ability to design and optimize the insulation design of the power transformer
CO4 Ability to understand the concept of insulation design of Instrument transformers and cable joints
CO5 Ability to understand the design concepts based on construction and arrester non-linear characteristics

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2		✓	✓			✓					✓	✓
CO3		✓	✓			✓					✓	✓
CO4		✓	✓			✓					✓	✓
CO5		✓	✓			✓					✓	✓

REFERENCES

1. Dieter Kind and Hermann Karner, “High Voltage insulation technology”, Translated from German by Y.Narayana Rao, Friedr. Vieweg&Sohn, Braunschweig, 1985.
2. Alston, L.L, “High Voltage Technology”, Oxford University Press, London 1968.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, Second edition.,2008.
4. Karsai, K.Kerenyi, D. and Kiss. L., “Large Power Transformers”, Elsevier, Armsterdam, 1987.
5. Feinberg, R., “Modern Power Transformer Practice”, The Macmillan Press Ltd., New York, 1979.
6. Looms, J.S.T., “Insulators for High Voltages”, IET, London, U.K, 1988.
7. S.V.Kulkarni, S.A.Khaparde, “Transformer Engineering Design and Practice”, Second edition, CRC press, New York, 2013.

HV5211 **INSULATION DESIGN LABORATORY** **LT P C**
0 0 4 2

COURSEOBJECTIVES:
To compute and analyse

- the electrical field distribution in homogeneous and non-homogeneous materials
- the various electric stress control methods
- the insulation design and appropriate stress control methods in Insulator, Bushing and cable joints.
- electric field distribution and transient response of transformer windings
- the insulation design and the transient response of Surge arrester

LIST OF EXPERIMENTS
The electric field analysis and the transient response of the equipment are to be carried out using Field computational software (FEM based) and Circuit simulation package respectively.

1. Electric field in homogeneous and non-homogeneous materials
   i. Symmetrical and asymmetrical electrode configurations
   ii. Parallel plate, coaxial cable and concentric spheres
2. Dielectric refraction of electric in practical insulation systems – Transverse, longitudinal and inclined boundary condition: electric field behavior for a finite contact angle.
3. Design of insulator with grading and corona rings
4. Design of condenser and non-condenser bushing
5. Design of cable joints
6. Transformer design
   i. Stress control techniques for different types of winding in transformer (layer, disc)
   ii. High frequency equivalent circuit model
   iii. Transient analysis
7. Insulation design of Surge Arrester

P= 60, TOTAL : 60 PERIODS

COURSEOUTCOMES:
CO1Ability to understand the field distribution and utilization for basic configurations
CO2 Gain knowledge in various stress control techniques for HV equipment
CO3 Ability to design high voltage insulators, bushing and cable joints
CO4 Ability to check the design of transformer insulation and apply suitable techniques to improve the design if necessary
CO5 Ability to improve the design of the surge arrester

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			✓		✓	✓	✓			✓	✓	✓
CO2			✓		✓	✓	✓			✓	✓	✓
CO3			✓		✓	✓	✓			✓	✓	✓
CO4			✓		✓	✓	✓			✓	✓	✓
CO5			✓		✓	✓	✓			✓	✓	✓

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HV5212 **ADVANCED HIGH VOLTAGE LABORATORY** **LT P C**
0 0 4 2

COURSEOBJECTIVES:

To acquire hands on experience

- on breakdown study of air, liquid and solid dielectrics under different electrode configurations and voltages
- to measure harmonics and E/H fields using meters
- to measure transient voltage distribution in transformer windings
- to measure and analyse the different types of Partial discharges
- on dielectric testing of high voltage equipment as per Standards

LIST OF EXPERIMENTS

1. Study on the AC and DC breakdown characteristics of air at different pressures
2. Study on the AC and Impulse voltage breakdown characteristics of Liquid Dielectrics
3. Study on the AC breakdown characteristics of Solid Dielectrics under Uniform and Non-Uniform fields
4. Measurement of Electric and Magnetic fields using field meters
5. Measurement of resonant frequencies and internal voltage distribution in transformer windings
6. Measurement of Partial Discharges
7. Measurement of Harmonics using energy analyzer
8. Dielectric withstand tests on Insulator / Bushing
9. Dielectric withstand tests on Air Break Switch / Circuit Breaker
10. Dielectric withstand tests on Transformer

P = 60 ,TOTAL = 60 PERIODS

COURSEOUTCOMES:

CO1 knowledge in breakdown characteristics of different types of dielectric media under different voltages and electrode configurations

CO2 Ability to check the E/H field exposure levels

CO3 Ability to analyze the transient behavior of transformer windings under various types of overvoltages

CO4 Ability to check the quality of the power and the equipment

CO5 Ability to test the power equipment asper standards for Certification purpose

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓						✓		
CO2				✓			✓			✓		✓
CO3				✓						✓		✓
CO4				✓		✓				✓		✓
CO5				✓		✓				✓		✓

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PROFESSIONAL ELECTIVE COURSES (PEC)

HV5001 DESIGN OF HIGH VOLTAGE SWITCHGEAR LT P C
3 0 0 3

COURSEOBJECTIVES:
To impart knowledge on,
- the clearances between contacts in different insulating media
- the arcing phenomenon in circuit breaker and model of arc.
- the design techniques and governing factors of air circuit breaker
- the design techniques and governing factors of oil circuit breakers
- the design techniques and governing factors of vacuum and SF_6 circuit breakers

UNIT I INTRODUCTION 9
Insulation of switchgear - coordination between inner and external insulation, Insulation clearances in air, oil, SF6 and vacuum, bushing insulation, solid insulating materials – dielectric and mechanical strength consideration – Isolating, earthing and load switches.

UNIT II CIRCUIT INTERRUPTION 9
Switchgear terminology – Arc characteristics – direct and alternating current interruption – arc quenching phenomena – computer simulation of arc models – transient re-striking voltage – RRRV-recovery voltage-current chopping-capacitive current breaking-auto re-closing.

UNIT III DESIGN OF AIR CIRCUIT BREAKERS 9
General Layout – Electric Arc Behavior in a Longitudinal Flow of Compressed Air – Thermodynamic Clogging of the Blast Nozzle, Nozzle Section Vs Breaking Current Relation – Recovery of Dielectric Strength in Axial Blast Interrupters – Aiding Arc Extinction with Shunt Resistors and Capacitors – Gas Dynamics of Air Circuit Breakers – Analysis and Selection of Interrupting Chamber Parameters – Control System Components – Air Circuit Breaker Design – Case studies

UNIT IV DESIGN OF OIL CIRCUIT BREAKERS 9
Layout of Bulk and Low-Oil Breakers – Construction and Operation of Interrupters – Extinction Chamber Pressure Analysis – Auto-Reclosing Duty and Frequent Make-Break Operations – Operating Mechanisms – Driving and Tripping Mechanisms – Trends in the Development of Oilless Circuit Breakers – Breaker Design – Case studies

UNIT V DESIGN OF SF_6 AND VACUUM CIRCUIT BREAKERS 9
Insulating and Interrupting Properties of SF6 –Analysis and Construction of SF6 Circuit Breakers – Vacuum circuit breakers: Status and trends in continuous current and interrupting ratings – Mechanical and thermal withstand capabilities– Construction and layout – Breaker design – Case studies

P=45: TOTAL = 45 PERIODS

COURSEOUTCOMES:
CO1: Ability to analyze insulation clearances in external and internal installations
CO2: Ability to analyze and model arc interruption in circuit breakers
CO3: Ability to design different air circuit breakers effectively
CO4: Ability to meet design trends in oil-less circuit breakers
CO5: Ability to design and analyze SF6 and VCB circuit breakers

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									
CO2	✓	✓									✓	
CO3	✓	✓									✓	
CO4	✓	✓					✓				✓	
CO5	✓	✓					✓				✓	

REFERENCES

1. Chunikhin, A. and Zhavoronkov, M., "High Voltage Switchgear Analysis and Design", Mir Publishers, Moscow, 1989.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2005
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4. Ananthakrishnan S and Guruprasad K.P., "Transient Recovery Voltage and Circuit Breakers", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1999.
5. Funio Nakanishi, "Switching Phenomena in High Voltage Circuit Breakers", Marcel Dekker Inc., New York, 1991.

HV5002 CONDITION MONITORING OF HIGH VOLTAGE POWER EQUIPMENT **L T P C 3 0 0 3**

COURSEOBJECTIVES:

- To provide strong knowledge on different types condition monitoring methods
- To impart knowledge in condition monitoring of
  - Transformers
  - Switchgear components
  - Rotating equipment
- To be aware of the latest and future trends in condition monitoring

UNIT I BASICS OF CONDITION MONITORING **9**

Need for Condition monitoring, Diagnostic methods- Requirements of diagnosis methods, design acceptance test , age related failure , insulation assessment methodologies, Destructive and non-destructive techniques, Offline and online condition monitoring, sensors.

UNIT II CONDITION MONITORING OF TRANSFORMERS **9**

Diagnostic test chart, Impulse fault analysis,, Partial discharge measurements and analysis Conventions diagnostic techniques- Chemical and electrical techniques , Dielectric response measurements in time domain and frequency domain – FRA

UNIT III CONDITION MONITORING OF SWITCHGEARS **9**

Need for monitoring, objectives for switching equipment monitoring, Diagnostic techniques for switching equipment- insulation, current carrying, switching, mechanical operation, control of auxiliary functions

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UNIT IV CONDITION MONITORING OF ROTATING EQUIPMENT 9

Failure modes -Stator and rotor failure mechanisms, Monitoring methods- temperature, chemical, vibration, current, flux, power and discharges

UNIT V FUTURE TRENDS 9

Reaming life analysis, Condition based maintenance and asset management, Introduction to Artificial Intelligence techniques ,latest methodologies and Future trends.

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1 Knowledge in the different types and methodologies of Condition monitoring practices
Ability to monitor the condition of
CO2 Transformers
CO3 Switchgear components
CO4 Rotating equipment
CO5 Knowledge in in future trends and tools for condition monitoring

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2				✓		✓						✓
CO3				✓		✓						✓
CO4				✓		✓						✓
CO5				✓		✓					✓	✓

REFERENCES

1. R.E.James and Q Su,"Condition Assessment of High Voltage Insulation in Power System Equipment",IET Power and Energy series 53, 2008.
2. Sivaji Chakrovorti, DEbangshuDey, Biswendu Chatterjee," Recent trends in the condition monitoring of transformers", Springer-Verlag, London 2013
3. PeterTavner, Li Ran, Jim Penman and Howard Sedding, ' condition montoring of rotating elelctricalmachines',IETPower and Energy series 56, 2008
4. G C Stone ,'ELECTRICAL INSULATION FOR ROTATING MACHINES Design, Evaluation, Aging, Testing, and Repair", IEEE Press
5. IEEE62, 62-1995 - IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors
6. IEC 60599 Interpretation of the analysis of gases in transformers and oil filled equipment in service
7. CIGRE TB No 462, Obtaining Value from On- Line Substation Condition Monitoring
8. CIGRE TB No 558., Guide for the Monitoring, Diagnosis and Prognosis of Large Motors.
9. CIGRE TB No 167, USER GUIDE FOR THE APPLICATION OF MONITORING AND DIAGNOSTIC TECHNIQUES FOR SWITCHING EQUIPMENT FOR RATED VOLTAGES OF 72.5 kV AND ABOVE.

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HV5003 **NANO DIELECTRICS** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

- To enable the students to become familiar with different types
- To understand the various properties of nano materials.
- To expose the knowledge on synthesization of nano materials.
- To impart knowledge on characterization methods of nano composites
- To obtain the idea about the application of nano polymers.

UNIT I INTRODUCTION TO NANO MATERIALS 9

Introduction to nanomaterials- Definition of nanocomposite, nanofillers, classification of nanofillers, carbon and non-carbon based nanofillers - Properties of nanomaterials- role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity in the macroscopic state

UNIT II PROPERTIES OF NANOMATERIALS 9

Nanocomposites and Properties- Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites: Dielectric and CMR based nanocomposites. Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity and Breakdown Strength, Refractive Index.

UNIT III SYNTHESIZATION AND CHARACTERIZATION METHODS 9

Synthesis of Nanomaterials by Physical Methods -Inert gas condensation, Arc discharge, Ball Milling, Molecular beam epitaxy-Chemical vapour deposition method and Electro deposition.

Chemical methods for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation, Sol-gel synthesis, Microwave heating synthesis, Sonochemical synthesis; Electrochemical synthesis; Photochemical synthesis.

Introduction to microscopy- Scanning Electron Microscopy, Transmission Electron Microscopy, Optical Absorption and Emission Spectroscopy, Thermogravimetric Analysis, Differential Scanning Calorimetry

UNIT IV NANOCOMPOSITE 9

Direct Mixing, Solution Mixing ,Preparation and characterization of inorganic nanofillersproperties ,synthesis, characterization and applications of SiO_2, TiO_2, ZrO_2, Al_2O_3 and CNTcomposite , Applications of nano filled materials for outdoor and indoor equipments.

UNIT V NANOPOLYMERS 9

Polymerization, Particle Processing Ceramic/Polymer Composites, Preparation and characterization of Copolymer based nano composites- Barrier properties of polymer nanocomposites- Permeation and diffusion models - Thermo Electric Materials – Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the nano material structure
CO2 Ability to understand the characteristics of nano materials.
CO3 Ability to understand the methods of synthesization and characterization.
CO4 Ability to understand the processing methods of nanocomposite and applications.
CO5 Ability to design and fabricate the electrical insulations with nano dielectric materials.

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CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2		✓	✓									
CO3			✓		✓	✓						
CO4					✓	✓						
CO5			✓		✓	✓						

REFERENCES

1. Handbook of Nanofabrication. Edited by Gary Wiederrcht. Elsevier, 2010.
2. Nanocomposite Science and Technology: by P.M. Ajayan, L.S. Schadler, P.V.Braun, 2003 WILEY-VCH Verlag GmbH Co. KGaA, Weinheim.
3. Nanoporous materials: Advance techniques for characterization, Modeling and Processing Edited by Nick KanelloPoulos. CRC press, 2011.
4. Inorganic Nanoparticles: Synthesis, Application and Perspectives. Edited by Claudia Altavilla and Enrico Ciliberto. CRC Press, 2011.
5. Polymer nanocomposites: by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
6. CRC Handbook of Thermoelectrics, Ed. CR Rowe.

HV5071 APPLICATIONS OF HIGH ELECTRIC FIELDS L T P C
3 0 0 3

COURSEOBJECTIVES:

To impart knowledge on,

- industrial applications of High electric fields
- in-activation of microbes by High electric fields
- food preservation by High electric fields
- High electric fields applications in cancer treatment
- the awareness on electro-static hazards and safety measures

UNIT I APPLICATION IN INDUSTRY 9

Introduction – electrostatic applications- electrostatic precipitation, separation , painting / coating, spraying ,imaging ,printing ,Transport of materials – Sandpaper Manufacture – Smoke particle detector – Electrostatic spinning ,pumping , propulsion – Ozone generation – Biomedical applications.

UNIT II APPLICATION IN MICROBIAL INACTIVATION 9

Introduction-definitions, descriptions and applications-mechanisms of microbial in-activationselectrical breakdown-electroporation-inactivation models -Critical factors-analysis of process, product and microbial factors-pulse generators and treatment chamber design-Research needs

UNIT III APPLICATION IN FOOD PRESERVATION 9

Processing of juices, milk, egg, meat and fish products- Processing of water and waste – Industrial feasibility, cost and efficiency analysis

UNIT IV APPLICATION IN CANCER TREATMENT 9

Different types of cancer – Different types of treatments, anti-cancer drugs – Electrochemotherapy – Electric fields in cancer tissues – Modeling, analysis of cancer tissues

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UNIT V SAFETY AND ELECTROSTATIC HAZARDS **9**

Introduction – Nature of static electricity – Triboelectric series – Basic laws of Electrostatic electricity– materials and static electricity – Electrostatic discharges (ESD) – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Static eliminators and charge neutralizers – Lightning protection- safety measures and standards

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to apply high electric fields in day-to-day life problems
CO2: Ability to apply high electric fields in microbial inactivation
CO3: Ability to preserve food by high electric fields
CO4: Ability to work in multidisciplinary projects like cancertreatment with high electric fields
CO5: Ability to provide safety measures against electrostatic hazards

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							✓				✓	
CO2				✓					✓			
CO3				✓				✓	✓			
CO4				✓					✓			
CO5							✓				✓	

REFERENCES

1. N.H.Malik, A.A.Ai-Arainy, M.I.Qureshi, “Electrical Insulation in power systems”, Marcel Dekker, inc., 1998.
2. Mazen Abdel-Salam, HussienAnis, Ahdab EI-Morshedy, “High Voltage Engineering”, Second Edition, Theory and Practice, Marcel Dekker, Inc. 2000,
3. John D.Kraus, Daniel A.Fleisch, “Electromagnetics with Applications” McGraw Hill International Editions, 1992.
4. Shoait Khan, “ Industrial Power System”, CRC Press, Taylor & Francis group, 2008.
5. G.V. Barbosa – Canovas, “Pulsed electric fields in food processing:Fundamental aspects and applications” CRC Publisher Edition March 1 2001.
6. H L M Lelieveld and Notermans.S,et.al., “Food preservation by pulsed electric fields: From research to application”, Woodhead Publishing Ltd. October 2007.
7. Indian Electricity Rules; IS-5216; Electrical Safety Handbook by John Cadick

HV5072 **DESIGN OF SUBSTATIONS** **L T P C**
3 0 0 3

COURSEOBJECTIVES:

- To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To obtain the knowledge about layout of AIS and GIS with proper Right of Way.
- To study the substation insulation co-ordination and protection scheme.
- To study the source and effect of fast transients in AIS and GIS.

UNIT I INTRODUCTION TO AIS AND GIS **9**

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS 9

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes- single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus

UNIT III INSULATION COORDINATION OF AIS AND GIS 9

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC standards.

UNIT IV GROUNDING AND SHIELDING 9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS 9

Introduction – Disconnector switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1 Ability to understand the fundamental components of **AIS AND GIS**.
CO2 Ability to understand the role of **major equipment and layout of AIS AND GIS**.
CO3 Ability to understand the **insulation coordination of AIS and GIS.**
CO4 Ability to understand the significance of **grounding and shielding.**
CO5 Ability to know about the effects of **fast transients in Substation equipment.**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3		✓	✓		✓	✓						
CO4				✓	✓	✓						
CO5			✓		✓	✓						

REFERENCES

1. Andrew R. Hileman, “Insulation coordination for power systems”, Taylor and Francis, 1999.
2. M.S. Naidu, “Gas Insulation Substations”, I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, “Surges in high voltage networks” Plenum Press,New York, 1980.
4. “Power Engineer’s handbook”, TNEB Association.
5. PritindraChowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2004.
6. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
7. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. on Power Apparatus and Systems, August 1953
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HV5073 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY LT P C
3 0 0 3

COURSE OBJECTIVES:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To know about the importance of Grounding and shielding.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- EMI predictions and modelling, Methods of eliminating interferences and noise mitigation

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling, inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems -hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the types and sources of EMI.
CO2 Ability to understand the needs of rounding and cabling.
CO3 Ability to understand the design concept of filtering and shielding.
CO4 Ability to studythe effect of EMI in elements and circuits.
CO5 Ability to know about the effects of electrostatic discharge and testing techniques.

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CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3			✓		✓		✓					
CO4			✓		✓							
CO5			✓		✓		✓					

REFERENCES

1. V.P. Kodali, “Engineering Electromagnetic Compatibility”, S. Chand, 1996.
2. Henry W.Ott, “ Noise reduction techniques in electronic systems”, John Wiley & Sons, 1989.
3. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
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6. Weston David A., “Electromagnetic Compatibility, Principles and Applications”, 1991.

HV5074 POLLUTION PERFORMANCE OF POWER APPARATUS AND SYSTEMS **LT P C 3 0 0 3**

COURSEOBJECTIVES:

To provide in-depth knowledge on

- the mechanism and effect of pollution
- Artificial and field pollution test methods

To the pollution performance of

- High voltage insulators
- surge diverters
- indoor equipment.

UNIT I INTRODUCTION **9**

Fundamental process of pollution flashover – development and effect of contamination layer – creepage distance – pollution conductivity – mechanism of pollution flashover – analytical determination of flashover voltage.

UNIT II POLLUTION TESTING **9**

Artificial pollution testing – salt-fog method – solid layer method – monitoring of parameters – measurement of layer conductivity – field testing methods., IS/IEC/IEEE Standard

UNIT III POLLUTION PERFORMANCE OF INSULATORS **9**

Ceramic and non-ceramic insulators – design of shed profiles – rib factor effect in AC and DC insulators – modelling

UNIT IV POLLUTION PERFORMANCE OF SURGE ARRESTERS **9**

External insulation – effect of pollution on the protective characteristics of gap and gapless arresters – modeling of surge diverters under polluted conditions.

UNIT V POLLUTION PERFORMANCE OF INDOOR EQUIPMENT **9**

Condensation and contamination of indoor switch gear – performance of organic insulator under polluted conditions – accelerated testing techniques.

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1 Ability to understand the mechanism and factors affecting the pollution performance
CO2 Ability to design and conduct pollution tests
CO3 Ability to design insulator profile based on pollution
CO4 Ability to understand the external insulation based on pollution
CO5 Ability to design indoor equipment

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2			✓	✓		✓						
CO3			✓	✓								
CO4			✓	✓								
CO5			✓	✓								

REFERENCES

1. Kind and Karner, “High Voltage Insulation”, Translated from German by Y.Narayana Rao, Frider. Vieweg, &Sohn, Braunschweig, Weishaden, 1985.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005.
3. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.

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6. Ravi S. Gorur, “Outdoor Insulators”, Inc. Phoenix, Arizona 85044, USA, 1999
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HV5075 PRINCIPLES OF ELECTRIC POWER TRANSMISSION LT P C
3 0 0 3

COURSEOBJECTIVES:

- To understand power system structure and line configurations
- To compute line parameters and understand effect of ground return
- To understand voltage gradients of transmission line conductors.
- To compute electrostatic field and design of EHV AC
- To design and know basic concepts of HVDC lines.

UNIT I INTRODUCTION 9

Standard transmission voltages-AC and DC – different line configurations– average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance

UNIT II CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – effect of ground return

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS 9

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers-I^2R loss and corona loss-RIV

UNIT IV ELECTROSTATIC FIELD AND DESIGN OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference, Design of EHV lines

UNIT V HVDC LINES 9

Introduction- Reliability and failure issues-Design-tower, ROW, clearances, insulators, electrical and mechanical protection-Maintenance-Control and protection-D.C Electric field and Magnetic field -Regulations and guide lines-under ground line design.

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to identify voltage level and line configurations
CO2: Ability to model EHV AC and HVDC lines
CO3: Ability to compute voltage gradients of transmission line conductors
CO4: Ability to understand effects of electrostatic field on living and nonliving organisms
CO5: Ability to coordinate the insulation level of the power system

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓					✓	✓					
CO2	✓	✓			✓							
CO3	✓			✓	✓	✓	✓					
CO4						✓	✓					
CO5		✓	✓		✓	✓	✓					

REFERENCES

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 2006.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 2009.
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4. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
5. Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition, Khanna Publishers, 2008
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8. J.C Molburg, J.A. Kavicky, and K.C. Picel ,"A report on The design, Construction and operation of Long-distance High-Voltage Electricity Transmission Technologies" , Argonne (National Laboratory)
9. P.Kundur,"Power system stability and control",McGraw-Hill,Inc.,1993
10. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd.,New Delhi, 2002.

CO5251 MACHINE LEARNING LT P C
3 1 0 4

COURSE OBJECTIVES

To educate the students

- On several fundamental concepts and methods for machine learning.
- And get acquaint with basic learning algorithms and techniques and their applications.
- Acquire knowledge in processing, analyzing and handling data sets.
- Demonstrate typical applications of various clustering based learning algorithms

UNIT 1 INTRODUCTION TO MACHINE LEARNING 12

Objectives of machine learning – Human learning/ Machine learning – Types of Machinelearning:- Supervised Learning – Unsupervised learning – Reinforcement Learning –Evolutionary Learning - Regression – Classification – The Machine Learning Process:- DataCollection and Preparation – Feature Selection – Algorithm Choice – Parameter and ModelSelection – Training – Evaluation.

UNIT II DATA PREPROCESSING 12

Data quality – Data preprocessing: - Data Cleaning:– Handling missing data and noisy data –Data integration:- Redundancy and correlation analysis – Data Reduction:- Dimensionalityreduction (Linear Discriminant Analysis – Principal Components Analysis – Factor Analysis –Independent Components Analysis) – Numerosity Reduction - Data Compression - DataNormalization and Data Discretization.

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UNIT III SUPERVISED LEARNING 12

Linearly separable and nonlinearly separable populations – Multi Layer Perceptron –Back propagation Learning Algorithm – Radial Basis Function Network – Support VectorMachines: - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm – Multi
Class Classification – Support Vector Regression.

UNIT IV CLUSTERING AND UNSUPERVISED LEARNING 12

Introduction – Clustering:- Partitioning Methods:- K-means algorithm - Hierarchical clustering –Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering - Self Organizing Map (SOM) - SOM algorithm.

UNIT V BAYESIAN LEARNING 12

Probability based clustering – The Expectation Maximization Algorithm – BayesianClassification – Bayesian Networks – Learning Bayesian Networks – Hidden Markov Models.

TOTAL:60PERIODS

COURSE OUTCOMES:

At the end of this course, the students will demonstrate the ability

- To understand the basic theory underlying machine learning.
- A range of machine learning algorithms along with their strengths and weaknesses.
- To formulate machine learning problems corresponding to different applications.
- To apply machine learning algorithms to solve problems of moderate complexity.
- To read current research papers and understand the issues raised by current research.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓		✓		✓						
CO2	✓	✓										
CO3	✓	✓			✓							✓
CO4	✓	✓				✓						✓
CO5	✓	✓		✓								✓

REFERENCES:

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2011.
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PS5151 ANALYSIS AND COMPUTATION OF ELECTROMAGNETIC TRANSIENTSINPOWER SYSTEMS

L T P C
3 1 0 4

COURSE OBJECTIVES

- To impart in depth knowledge aboutvarious power system transientsand analyze the travelling wave phenomena.
- To impart knowledge on the EMTP Type modelling of overhead lines and underground cables.
- To impart knowledge on the EMTP Type modelling of transformers.
- To coordinate the insulation of power system and protective devices.
- To describe the methodology for computing the transients in power systems.

UNITI REVIEW OF TRAVELLINGWAVE PHENOMENA 12

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behavior of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion-switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced byfault; very fast transient overvoltage(VFTO).

UNIT II PARAMETERS AND MODELLING OFOVERHEADLINES AND UNDERGROUNDCABLES 12

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on un-transposed lines; effect of ground return and skin effect; transposition schemes; introduction to frequency-dependent line modelling.Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single- core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters

UNIT III PARAMETERS AND MODELLING OF TRANSFORMER 12

Transformer modelling guidelines for transient phenomena – Generalization of [R]-[ωL] model single phase N-coil transformer-Generalization of [R]-[ωL]-1 model single phase N-coil transformer- Inverse Inductance Matrix representation of three-phase N-coil transformers- inclusion of exciting current.

UNIT IV INSULATION CO-ORDINATION 12

Insulation co-ordination –volt –time characteristics , Insulation strength and their selection-Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 12

Digital computation of line parameters: why line parameter evaluation programs? salient features of a typical line parameter evaluation program; constructional features of that affect transmission line parameters; line parameters for physical and equivalent phase conductors elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of electromagnetic transients program; steady state and time step solution modules: basic solution methods; case studies on simulation of various types of transients and insulation co-ordination.

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TOTAL: 60 PERIODS

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COURSE OUTCOMES

Students will be able to:

CO1: Understand and analyse the different types of transients.
CO2: Model overhead lines and cables and for transient studies.
CO3: Model transformers for transient studies.
CO4: Design a reliable power system with appropriate insulation coordination.
CO5: Compute different types of transients in power systems.

MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓	✓							
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓							

REFERENCES

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991.
2. R. Ramanujam, Computational Electromagnetic Transients: Modelling, Solution Methods and Simulation, I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, ISBN 978-93- 82332-74-9, 2014; email: info@ikinternational.com
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5. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi,2004.
6. Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor &Francis Group, New York, 1999.

PS5251 **HVDC AND FACTS** **L T P C**
3 1 0 4

COURSE OBJECTIVES

- To impart knowledge on the need for HVDC and FACTS.
- To impart in depth knowledge the operation, modelling and control of thyristor based FACTS controllers.
- To have an in-depth knowledge on the operation, modelling and control of LCC basedHVDC link.
- To have an in-depth knowledge on the operation, modelling and control of VSC basedHVDC link and FACTS controllers.
- To analyze the interaction of AC- DC systems through Power flow analysis.

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UNIT I INTRODUCTION **12**

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-Review of basics of LCC and VSC HVDC system.

UNIT II THYRISTOR BASED FACTS **12**

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for power flow analysis-Stability studies- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line-Concepts of Controlled Series Compensation – Operation of TCSC- Analysis of TCSC – Modelling of TCSC for power flow and stability studies.

UNIT III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL **12**

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS AND HVDC CONTROLLERS **12**

Static synchronous compensator (STATCOM) - Static synchronous series compensator (SSSC) Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers (UPFC) - Modelling of UPFC and IPFC for power flow and transient stability studies- ApplicationsVSC based HVDC: Operation, Modelling for steady state and dynamic studies.

UNIT V POWER FLOW ANALYSIS OF AC/DC SYSTEMS **12**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow-Solution of AC-DC power flow:Sequential and Simultaneous methods.

TOTAL: 60 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand the basics of power transmission networks and need for HVDC and FACTS controllers.
CO2: Analyze the operation, control and application of thyristor based FACTS controllers.
CO3: Analyze the operation, control and application of LCC based HVDC link .
CO4: Analyze the operation, control and application of VSC based HVDC link .
CO5: Model HVDC and FACTS for Power Flow studies.

MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓	✓			✓				
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓	✓						✓

Attested

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9. Narain G.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technologyof Flexible AC Transmission System”, Standard Publishers, Delhi 2001.

PS5075 **SMART GRID**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

Students will be able to:

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understanding the problems associated with integration of distributed generation & its solution through smart grid.
- To familiarize the high performance computing for Smart Gridapplications

UNIT I INTRODUCTION TO SMART GRID 9

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

UNIT II SMART GRID TECHNOLOGIES (Transmission) 9

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

UNIT III SMART GRID TECHNOLOGIES (Distribution) 9

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

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

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

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Computing algorithms for Smart grid, IOT, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand on the concepts of Smart Grid and its present developments.
CO2: Analyze about different Smart Grid transmission technologies.
CO3: Analyze about different Smart Grid distribution technologies.
CO4: Acquire knowledge about different smart meters and advanced metering infrastructure.
CO5: Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓				✓	✓	✓					
CO2	✓				✓	✓	✓					
CO3	✓				✓	✓	✓					
CO4	✓				✓	✓	✓					
CO5	✓				✓	✓	✓			✓		

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2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”,Wiley.
3. Vehbi C. Gungor, DilanSahin, TaskinKocak, Salih Ergut, Concettina Buccella, Carlo Cecati ,and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies andStandards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.

PS5071 APPLICATION OF AI TECHNIQUES TO POWER SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVES

- Formulatingthe optimization problems using ANN.
- Using appropriate ANN framework for solving power system problems.
- Using Fuzzy Logic for optimization problems
- Formulatingthe optimization problems using GA
- Applyingdifferent Artificial Intelligence techniques for optimizing power system problems.

UNIT I ARTIFICIAL NEURAL NETWORKS 9

Introduction Models of Neuron Network – Architectures – Knowledge representation – Artificial Intelligence and Neural networks–Learning process – Error correction learning – Hebbian learning– Competitive learning – Boltzmann learning –Supervised learning – Unsupervised learning – Reinforcement learning – learning tasks

UNIT II ANN PARADIGMS **9**

Multi – layer perceptron using Back propagation Algorithm (BPA) – Self – Organizing Map (SOM) – Radial Basis Function Network – Functional Link Network (FLN) – Hopfield Network.

UNIT III FUZZY LOGIC **9**

Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy Cartesian Product – operations on Fuzzy relations – Fuzzy-logic – Fuzzy Quantifiers–Fuzzy Inference – Fuzzy Rule based system–Defuzzification methods.

UNIT IV GENETIC ALGORITHMS **9**

Introduction–Encoding – Fitness Function–Reproduction operators–Genetic Modeling – Genetic operators–Cross over – Single site cross over – Two point cross over – Multi point cross over – Uniform cross over – Matrix cross over–Cross over Rate –Inversion & Deletion – Mutation operator– Mutation – Mutation Rate–Bit–wise operators –Generational cycle – convergence of Genetic Algorithm.

UNIT V APPLICATIONS OF AI TECHNIQUES **9**

Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1: Learn problem formulation using Artificial Neural Network.
CO2: Choose methodology suiting the problem statement.
CO3: Learn Fuzzy Logic based implementation of optimization problem
CO4: Learn problem formulation using Genetic Algorithm
CO5: Apply ANN, Fuzzy Logic and Genetic Algorithm for Power System Optimization Problem

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓						✓	
CO2	✓	✓	✓	✓	✓						✓	
CO3	✓	✓	✓		✓						✓	
CO4	✓	✓	✓	✓	✓						✓	
CO5	✓	✓	✓	✓	✓						✓	

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Attested

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PS5076 **WIND ENERGYCONVERSIONSYSTEM** **LT P C**
3 0 0 3

COURSE OBJECTIVES

- To learn about the basic concepts of wind energy conversion system
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of Variable speed wind energy conversion systems.
- To analyze the grid integration issues.

UNITI INTRODUCTION **9**

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WINDTURBINES **9**

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXEDSPEEDSYSTEMS **9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLESPEED SYSTEMS **9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V GRIDCONNECTED SYSTEMS **9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Attain knowledge on the basic concepts of Wind energy conversion system.
CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine
CO3: Develop more understanding on the design of Fixed speed system
CO4: Study about the need of Variable speed system and its modelling.
CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓		✓		✓							
CO3	✓		✓									
CO4	✓		✓		✓							
CO5	✓	✓	✓	✓								

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5. N. Jenkins,” Wind Energy Technology” John Wiley &Sons,1997
6. S.Heir “Grid Integration of WECS”, Wiley1998.

PS5252	RESTRUCTURED POWER SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Students will be able to:

- describe various types of deregulated markets in power system.
- describe the technical and non-technical issues in deregulated power industry.
- classify different market mechanisms and summarize the role of various entities in the market.
- analyze the energy and ancillary services management in deregulated power industry.
- understand the restructuring framework US and Indian power sector

UNIT I INTRODUCTION 9

Reasons for restructuring - Understanding the restructuring process - objectives of deregulation of various power systems across the world - Consumer behavior - Supplier behavior - Market equilibrium - Short-run and Long-run costs - Various costs of production. The Philosophy of Market Models**:** Market models based on contractual arrangements - Market architecture - .

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Non-market methods - Market based methods - Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management - Capacity alleviation method.

UNITIII LOCATIONAL MARGINAL PRICES(LMP) AND FINANCIAL TRANSMISSION RIGHTS 9

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality Of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs **-** Flow Gate rights - FTR and market power

UNITIV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Types of ancillary services - Load-generation balancing related services - Voltage control and reactive power support services - Black start capability service - Mandatory provision of ancillary services - Markets for ancillary services - Co-optimization of energy and reserve services - International comparison. Pricing of transmission network**:** wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm - loss allocation methods

UNIT V MARKET EVOLUTION **9**

US markets: PJM market - The Nordic power market **-** Reforms in Indian power sector**:** Framework of Indian power sector - Reform initiatives - availability based tariff (ABT) - The Electricity Act 2012 - Open Access issues - Power exchange

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: describe the requirement for deregulation of the electricity market and the philosophy of various market models
CO2: analyze the various methods of congestion management in deregulated power system
CO3: analyze the locational marginal pricing and financial transmission rights
CO4: analyze the ancillary service management
CO5: understand the framework of Indian power sector

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓					✓	✓					
CO2	✓	✓	✓			✓						
CO3	✓	✓	✓			✓						
CO4	✓	✓	✓			✓						
CO5	✓					✓	✓	✓				

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3. SallyHunt, "Makingcompetitionworkinelectricity”,JohnWilleyandSonsInc.2002.
4. StevenStoft," Power System Economics: Designing Markets for Electricity”,Wiley-IEEE Press, 2002.
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PS5074 OPTIMISATIONTECHNIQUES **LT P C**
3 0 0 3

COURSE OBJECTIVES

Students will be able to:

- understand the classificationof optimization
- study the linear programmingmodels and solution techniques
- study the different non-linear programmingproblem solution techniques
- understand the concept of dynamic programming
- study the fundamentals genetic algorithm and it applications.

UNITI INTRODUCTION **9**

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

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UNITII LINEARPROGRAMMING (LP) **9**

Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

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UNITIII NONLINEAR PROGRAMMING **9**

Steepest descent method, conjugates gradient method, Newton's Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.

UNITIV DYNAMICPROGRAMMING (DP) **9**

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

UNITV GENETICALGORITHM **9**

Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA, Applications to power system.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: learn about different classifications of optimization problems and techniques.
CO2: attain knowledge on linear programming concepts
CO3: understand the application of non-linear programming in optimization techniques
CO4: understand the fundamental concepts of dynamic programming
CO5: gain knowledge about Genetic algorithm and its application topower system optimization.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓	✓										
CO3	✓	✓										
CO4	✓	✓										
CO5	✓	✓			✓							

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2. Hamdy A. Taha, Operations Research: An Introduction, 10th Edition, Pearson, 2016.
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PS5072 APPLICATION OF DSP TO POWER SYSTEM PROTECTION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To expose the students to learn about DFT and Wavelet transforms.
- To provide an in-depth knowledgeon the components used for the implementation of digital protection.
- To impart knowledge on different algorithms for digital protection of power system components.
- To implement digital protection for transformer.
- To understand different decision making methodologies in protective relays.

UNIT I DIGITAL SIGNAL PROCESSING TECHNIQUES 9

Sampling-Principle of scaling-aliasing-Decimation, Interpolation. Fourier and discrete Fourier transforms - Fast Fourier Transforms.-Wavelet transform -Numerical Algorithms

UNIT II DIGITAL PROTECTION 9

Digital Protection -performance and operational characteristics of digital protection. Basic components of digital relays -Signal conditioning sub systems -Conversion subsystem -digital relay subsystem-Digital relay as a unit.

UNIT III ALGORITHMIC TECHNIQUES 9

Finite difference techniques- Interpolation-Numerical differentiation-curve fitting and smoothing. Sinusoidal wave based algorithms -First and second derivative method -two and three sample technique .Walsh function analysis- least squares based methods-differential equation based techniques -Travelling wave protective schemes.FIR based algorithms-Least square curve fitting algorithm.

UNIT IV DIGITAL PROTECTION TECHNIQUES 9

Transformer protection- -Fourier based algorithm-basic hardware of microprocessor based transformer protection .Digital line differential scheme. Measurement algorithms for digital protection -power-voltage -current -Impedance -phase shift.

UNIT V DIGITAL PROTECTIVE RELAYS 9

Decision making in protective relays- Deterministic Decision Making - Statistical Hypotheses Testing - Decision Making with Multiple Criteria - Adaptive Decision Schemes .Elements of Fuzzy Logic in Protective Relays -Fuzzy Sets and Fuzzy Numbers -Boolean Versus Fuzzy Logic -Fuzzy Reasoning - Fuzzy Logic Applications for Protection and Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: The students will be able to apply DSP techniques for digital protection.
CO2: The students will be capable of decision making algorithm suitable for digital relaying applications.
CO3: The students will be able to employ FIR based algorithms for digital relaying.
CO4: The students will be able to do transformer protection using digital techniques.
CO5: The students will be able to perform coordinated operation of relays for specific purposes.

MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							
CO2	✓	✓	✓	✓	✓							

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CO3	✓	✓	✓	✓	✓			✓				
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓	✓						✓

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3. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms
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PW5153 MODERN POWER SYSTEM ENGINEERING L T P C
3 1 0 4

COURSE OBJECTIVES:

- To apply iterative techniques for power flow analysis
- To provide knowledge about state estimation
- To analyse the power system security under different contingency events
- To gain knowledge about power system protection.
- To provide basic knowledge on voltage stability

UNIT I POWER FLOW ANALYSIS 12

Problem Formulation: Review of NR method, Fast Decoupled Load Flow– Distribution Load Flow: Ladder Iterative Technique, Three phase load flow solutions.

UNIT II STATE ESTIMATION 12

Introduction–Maximum Likelihood Weighted Least Squares Estimation–State Estimation of an AC Network– State Estimation by Orthogonal Decomposition – Use of Phasor Measurement Units – Applications of Power Systems State Estimation

UNIT III POWER SYSTEM SECURITY 12

Introduction–Factors Affecting Power System Security – Contingency Analysis: Generation outages, Transmission outages – Linear Sensitivity Factors – Voltage Collapse

UNIT IV POWER SYSTEM PROTECTION 12

Introduction to Power System Protection– Operating principles and Relay Construction – Overcurrent Protection– Microprocessor based Overcurrent Relays

UNIT V VOLTAGE STABILITY 12

Single-Load Infinite-Bus System– Maximum Deliverable Power– Power-Voltage Relationships– Generator Reactive Power Requirement– Instability Mechanisms– Effect of Compensation– VQ Curves.

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TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to carry out power flow analysis for transmission and distribution network.

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CO2: Able to Compute the state of the power system.
CO3: Ability to carry out contingency analysis to analyse power system security.
CO4: Able to understand over current protection for system security.
CO5: Analyse the concept of voltage stability.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓								
CO4	✓			✓								
CO5	✓	✓	✓	✓								

REFERENCES:

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2. Badri Ram and D. N. Vishwakarma, 'Power System Protection and Switchgear', McGraw-Hill, 1995.
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PW5151 CLIMATE CHANGE AND ENERGY ENVIRONMENT **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To provide knowledge about climate change and its environmental impact
- To give exposure about technology and policy options for GHG emission
- To provide knowledge about international climate change conventions, protocols and perspectives.
- To know the environmental problems related to energy use.
- To know the various options to improve the energy use.

UNIT I CLIMATE CHANGE **9**

Energy use and Global Warming, Climate Change Concerns, Climate Change in India, the Greenhouse Effect, Earth's Radiation balance, Greenhouse Gases (GHG) types and Sources, Climate Change Impacts.

UNIT II TECHNOLOGY AND POLICY OPTIONS FOR GHG EMISSION MITIGATION **9**

Renewable Energy, Energy Efficient Technologies by Sector and End-Use, Cleaner Production, Barriers to GHG Mitigation Technologies, Carbon tax and Tradable Emission Permits, Other Policy Options.

UNIT III INTERNATIONAL CLIMATE CHANGE CONVENTIONS, PROTOCOLSAND PERSPECTIVES **9**

Climate Change in India and mitigation measures on Indian perspectives, United Nations Framework Convention on Climate Change (UNFCCC), Clean Development Mechanism (CDM) as per the Kyoto Protocol and Flexible Mechanisms, comparison on India vs developed countries perspectives on GHG mitigations.

UNIT IV ENVIRONMENTAL PROBLEMS RELATED TO ENERGY USE **9**

Energy use and its air pollution, acid rain, Technological and policy options for control of SO_2 and NOx emissions, the problem of Atmospheric Brown Cloud (ABC) and possible mitigation options.

UNIT V URBAN ENERGY USE AND THE ENVIRONMENT **9**

Efficient/cleaner transport options of electric vehicles and their effects on energy use, environment and GHG emissions, other options to improve energy use and environment in urban areas.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Able to understand the climate change and its environmental impact.
CO2: Acquired knowledge about technology and policy options for GHG emission.
CO3: Ability to understand the international climate change conventions, protocols and perspectives.
CO4: Learned the environmental problems related to energy use.
CO5: Ability to identify the various options to improve the energy use.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓			✓			✓	✓				
CO2	✓		✓					✓				
CO3	✓	✓	✓									
CO4	✓	✓					✓				✓	
CO5	✓	✓					✓					✓

REFERENCES:

1. R. T. Watson, M. C. Zinyowera, and R. H. Moss (eds.),'Technologies, Policies, and Measures for Mitigating Climate Change', IPCC Technical Paper No. 1, Intergovernmental Panel on Climate Change, 1996.
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PW5251 **ENERGY MANAGEMENT AND AUDIT** **LT P C**
3 1 0 4

COURSE OBJECTIVES:

- To study the concepts behind economic analysis and Load management.
- To understand the basics of materials and energy balance.
- To analyze the energy efficiency in thermal utilities.
- To know the concept of compressed air system.
- To illustrate the concept of lighting systems and cogeneration.

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UNIT I GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT 12

Commercial and Non-commercial energy - final energy consumption - energy needs of growing economy - energy pricing - energy conservation and its importance - Re-structuring of the energy supply sector - Energy Conservation Act 2001, Energy Conservation (Amendment) Act, 2010, and its features - electricity tariff - Thermal Basics - need and types of energy audit - Energy management/audit approach- understanding energy costs - maximizing system efficiencies - optimizing the input energy requirements - energy audit instruments - Case study.

UNIT II MATERIAL AND ENERGY BALANCE 12

Methods for preparing process flow - material and energy balance diagrams - Energy policy purpose - location of energy management - roles and responsibilities of energy manager – employees training and planning- Financial Management:financial analysis techniques, simple payback period, return on investment, net present value, internal rate of return – Case Study.

UNIT III ENERGY EFFICIENCY IN THERMAL UTILITIES 12

Introduction to fuels - properties of fuel oil, coal and gas - principles of combustion - combustion of oil, coal and gas - Boilers: Types, combustion in boilers, performances evaluation, analysis of losses - energy conservation opportunities - FBC boilers - Steam System: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings - Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery – Refractory : types, selection and application of refractories, heat loss - Cogeneration: classification and saving potentials - Case Study.

UNIT IV ENERGY EFFICIENCY IN COMPRESSED AIR SYSTEM 12

Compressed Air System: Types of air compressors - efficient compressor operation - Compressed air system components - leakage test - savings opportunities - Refrigeration System: Vapour compression refrigeration cycle – refrigerants - coefficient of performance - factors affecting Refrigeration and Air conditioning system - savings opportunities - Vapour absorption refrigeration system: working principle - types and comparison with vapour compression system - saving potential - Cooling Tower: Types and performance evaluation, efficient system operation - flow control strategies and energy saving - Diesel Generating system: Factors affecting selection - energy performance assessment of diesel conservation avenues - Case Study.

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UNIT V ENERGY EFFICIENCY IN ELECTRICAL UTILITIES 12

Electrical load management and maximum demand control - power factor improvement and its benefit - selection and location of capacitors - performance assessment of PF capacitors - automatic power factor controllers - transformer losses - Electric motors: Types - losses in induction motors - motor efficiency - factors affecting motor performance - rewinding and motor replacement issues - energy saving opportunities with energy efficient motors - soft starters with energy saver - variable speed drives – Fans and blowers: Types - efficient system operation - flow control strategies -Pumps and Pumping System: Types - system operation - flow control methods - Lighting System: Light source, choice of lighting, luminance requirements – ballast - occupancy sensors - energy efficient lighting controls - energy conservation avenues - Case Study.

TOTAL: 60 PERIODS

COURSEOUTCOMES:

CO1: Students able to acquire knowledge in the field of energy management and auditing process.
CO2: Learned the about basic concepts of economic analysis and load management.
CO3: Able to design the effective thermal utility system.
CO4: Able to improve the efficiency in compressed air system.
CO5: Acquired the design concepts in the field of lighting systems, light sources and various forms of cogeneration.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓								
CO2	✓						✓		✓		✓	
CO3	✓		✓	✓	✓							
CO4	✓	✓							✓			
CO5	✓		✓	✓							✓	

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1. Moncef Krati, 'Energy Audit of Building Systems: An Engineering Approach', Second Edition, CRC Press, 2016.
2. Sonal Desai, 'Handbook of Energy Audit', McGraw Hill Education (India) Private Limited, 2015.
3. Michael P.Deru, Jim Kelsey, 'Procedures for Commercial Building Energy Audits', American Society of Heating, Refrigerating and Air conditioning Engineers, 2011.
4. Thomas D.Eastop, 'Energy Efficiency: For Engineers and Technologists', Longman Scientific & Technical, 1990.
5. 'Energy Managers and Energy Auditors Guide book',Bureau of Energy Efficiency, 2006.
6. Larry C. Witte, Philip S.Schmidt, David R.Brown, 'Industrial Energy Management and Utilization', Springer Berlin Heidelberg, 1988.

PW5077 RENEWABLE ENERGY TECHNOLOGY LT P C
3 0 0 3

COURSEOBJECTIVES

- To Provide knowledge about various renewable energy technologies
- To enable students to understand and design a PV system.
- To provide knowledge about wind energy system.
- To Provide knowledge about various possible hybrid energy systems
- To gain knowledge about application of various renewable energy technologies

UNIT I INTRODUCTION 9

Primary energy sources, renewable vs. non-renewable primary energy sources, renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.

UNITII SOLAR ENERGY 9

Solar Radiation and its measurements, Solar Thermal Energy Conversion from plate Solar Collectors, Concentrating Collectors and its Types , Efficiency and performance of collectors, Applications of Solar Thermal Energy use of low and medium, high temperature and recent advances in industry and buildings. Direct Solar Electricity Conversion from Photovoltaic, types of solar cells and its application of battery charger, domestic lighting, street lighting, and water pumping, power generation schemes. Recent Advances in PV Applications: Building Integrated PV, Grid Connected PV Systems, Hybrid Systems and Solar Cars, Solar Energy Storage system and their economic aspects.

UNIT III WIND ENERGY 9

Wind energy principles, wind site and its resource assessment, wind assessment, Factors influencing wind, wind turbine components, wind energy conversion systems (WECS), Classification of WECS devices, wind electric generating and control systems, characteristics and applications. Hybrid systems - safety and environmental aspects, economic aspects.

UNIT IV BIO-ENERGY **9**

Energy from biomass, Principle of biomass conversion technologies/process and their classification, Bio gas generation, types of biogas plants, selection of site for biogas plant, classification of biogas plants, Advantage and disadvantages of biogas generation, thermal gasification of biomass, biomass gasifies, Application of biomass and biogas plants and their economics.

UNIT V OTHER TYPES OF ENERGY **9**

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Attained knowledge about various renewable energy technologies
CO2: Ability to understand and design a PV system.
CO3: Understand the concept of various wind energy system.
CO4: Gained knowledge about various possible hybrid energy systems
CO5: Attained knowledge about various application of renewable energy technologies

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓		✓									
CO3	✓		✓									
CO4	✓		✓									
CO5			✓									

REFERENCES

1. Twidell & Wier,**'**Renewable Energy Resources' CRC Press(Taylor & Francis).
2. Tiwari and Ghosal/ Narosa,'Renewable energy resources'.
3. D.P.Kothari,K.C.Singhal,'Renewable energy sources and emerging technologies', P.H.I.
4. D.S.Chauhan, S.K. Srivastava, 'Non – Conventional Energy Resources', New Age Publishers, 2006.
5. B.H.Khan, 'Non – Conventional Energy Resources', Tata Mc Graw Hill, 2006.

PW5071 ELECTRIC VEHICLES AND POWER MANAGEMENT **L T P C**
3 0 0 3

COURSEOBJECTIVES:

- To provide knowledge about electric vehicle architecture and power train components.
- To know the concepts of dynamics of electrical vehicles
- To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs)
- To understand the concept of energy storage systems.
- To provide knowledge about different energy sources and energy management in HEVs.

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS **9**

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES **9**

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

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

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

UNIT IV ENERGY STORAGE SYSTEMS **9**

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. **Alternate sources:** Fuel cells, Ultra capacitors, Fly wheels.

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT **9**

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode - energy management of HEV's.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Learned the electric vehicle architecture and power train components.
CO2: Acquired the concepts of dynamics of electrical vehicles
CO3: Able to understand the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs).
CO4: Ability to design and select energy storage systems.
CO5: Acquired the knowledge of different energy sources and energy management in HEVs.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓							
CO2	✓	✓	✓						✓			
CO3	✓			✓		✓	✓					
CO4	✓	✓	✓		✓							
CO5	✓		✓								✓	

REFERENCES:

1. Iqbal Husain, 'Electric and Hybrid Electric Vehicles', CRC Press, 2011.
2. Wei Liu, 'Hybrid Electric Vehicle System Modeling and Control', Second Edition, WILEY, 2017.
3. James Larminie and John Lowry, 'Electric Vehicle Technology Explained', Second Edition, 2012.

PW5072 **ENERGY EFFICIENT BUILDINGS** **LT P C**
3 0 0 3

COURSEOBJECTIVES:

- To understand the different climate zones and modelling methods
- To understand about the principle of energy conscious building design.
- To understand about the concept of passive solar heating and efficient technologies in electrical system.
- To provide knowledge about the energy conservation techniques in buildings.

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- To provide knowledge about energy efficient technologies.

UNIT I CLIMATE AND SHELTER 9

Historic buildings – Modern architecture – Examples from different climate zones –Thermal comfort – Solar geometry and shading – Energy modeling techniques– Integrative Modeling methods and building simulation.

UNIT II PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN 9

Energy conservation in buildings – Day lighting – Solar based Water heating - Advances in thermal insulation – Heat gain/loss through building components - Solar architecture.

UNIT III PASSIVE SOLAR HEATING 9

Basics of Passive solar – Mechanical Systems – South Facing Glass – Thermal mass – Orientation – site planning for solar access - Direct gain – thermal storage wall – Sunspace –Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Design guidelines and natural cooling guidelines.

UNIT IV ENERGY CONSERVATION IN BUILDING 9

Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles – ECBC applicability – Building Envelope – Comfort system and controls – Lighting – Electrical Power and Renewable Energy.

UNIT V EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9

Maximum demand controllers, automatic power factor controllers, energy efficient motors, and soft starters – Energy efficient Lighting and Transformers.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Able to understand the different climate zones and modelling methods
CO2: Able to design energy conscious building design.
CO3: Able to understand about the concept of passive solar heating and efficient technologies in electrical system.
CO4: Able to gain knowledge about the energy conservation techniques in buildings.
CO5: Know about different energy efficient technologies.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2			✓									
CO3			✓	✓								
CO4			✓									
CO5			✓	✓								

REFERENCES

1. Joseph Clarke, 'Energy Simulation in Building Design', II Edition, Butterworth, 2001.
2. J. K. Nayak and J. A. Prajapati, 'Handbook on Energy Conscious Buildings', Solar Energy Centre, MNES, May 2006.
3. 'Energy conservation Building Codes – 2017', Bureau of Energy Efficiency.
4. 'Passive Solar Building - Design Strategies', Guidelines for home passive solar industries council, National Renewable Energy Laboratory and Charles Elay Associates.
5. J. Douglas Batcomb, 'Passive Solar Building',The MIT Press, 1992.
6. Thomas H.Kuehn, James W. Ramsey and J. L. Threlkeld, 'Thermal Environmental Engineering', 3rd Edition Prentice Hall, 1970.

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PW5073 ENERGY FORECASTING, MODELLING AND PROJECT MANAGEMENT **L T P C**
3 0 0 3

COURSEOBJECTIVES:

- To analyze the energy availability & changing pattern
- To analyze different forecasting models.
- To learn different optimization techniques for energy planning.
- To equip the students in writing project proposals and making project cost estimation.
- To learn about the different energy policy.

UNIT I ENERGY SCENARIO **9**

Role of energy in economic development and social transformation: Energy & GDP,GNP and itsdynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status and future promise.

UNIT II FORECASTING MODEL **9**

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponential Smoothing – ARIMA model - Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works.

UNIT III OPTIMIZATION MODEL **9**

Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT IV PROJECT MANAGEMENT **9**

Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.

UNIT V ENERGY POLICY **9**

National & State Level Energy Issues - National & State Energy Policy - Energy Security – National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs).

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1: Knowledge in Energy pattern and availability.
CO2: Ability to apply forecasting techniques.
CO3: Able to develop optimization model for energy planning
CO4: Equipped to write project proposal and cost estimation.
CO5: Acquired knowledge of national and state energy policies

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2		✓			✓							
CO3		✓			✓							
CO4											✓	
CO5		✓				✓						

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REFERENCES

1. Armstrong J.Scott, 'Principles of forecasting: a hand book for researchers and practitioners', Norwell, Massachusetts:Kluwer Academic Publishers.2001.
2. Austin H. Church, 'Centrifugal pumps and blowers', John Wiley and sons, 1980.
3. Dhandapani Alagiri, 'Energy Security in India Current Scenario', The ICFAI University Press,2006.
4. Fred Luthans, 'Organisational Behaviour', McGraw Hill, lnc, USA, 1992.
5. S. Makridakis, 'Forecasting Methods and applications', Wiley, 1983.
6. Sukhvinder Kaur Multani, 'Energy Security in Asia Current Scenario', The ICFAI UniversityPress, 2008.
7. Yang X.S., 'Introduction to mathematical optimization: From linear programming to Metaheuristics', Cambridge, Int. Science Publishing, 2008.

PW5152 ENERGY CONSERVATION IN ELECTRICAL SYSTEMS LT P C
3 0 0 3

COURSEOBJECTIVES:

- To study the concepts of power factor, load management.
- To study the various measures for energy conservation in electrical devices both static & rotating machineries.
- To understand the energy conservation in pump and compressor systems.
- To study the performance of lighting systems.
- To understand the concept of PAT systems and cost factor.

UNIT I ELECTRICAL ENERGY USAGE : BASICS 9

Cascade Efficiency – Electricity Billing : components and Costs – kVA – need and Control – Determination of kVA and Consumption – Tariff – power factor – poor power factor impact and penalty – power factor correction methods – demand side management.

UNIT II TRANSFORMERS AND MOTORS 9

Transformer : Basics - types – specification and selection of Transformers - AVR and OLTC concepts – performance prediction – efficiency improvement in transformers - Motors: specification and selection – efficiency / load curve – load estimation – assessment of Motor performance under different operating conditions – factors affecting performance – over sizing - effects of rewinding energy efficient motors - ENCON Scope.

UNIT III FANS, PUMPS AND COMPRESSORS 9

Operation – selection – performance evaluation – cause for inefficient operation – possibility for energy conservation – methods adopted for effecting ENCON – economics of ENCON adoption in all the utilities.

UNIT IV ILLUMINATION AND ENERGY EFFICIENCY DEVICES 9

Specification of Luminaries – types – efficacy – selection and application – ENCON avenues and economic proposition - new generation luminaries (LED / Induction Lighting) - soft starters - auto star – delta starters - variable speed and frequency drives – time sensors –occupancy sensors.

UNIT V CASE STUDIES & CO_2 MITIGATION 9

Case Study Evaluation for 3/4 Typical Sectors – introduction to PAT Scheme – CO2 Mitigation, Energy Conservation & Cost Factor.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Able to know the importance of power factor improvement.
CO2: Learned the various measures for energy conservation in electrical devices.
CO3: Able to improve the energy efficiency in pump and compressor systems.

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CO4: Able to design effective lighting systems.
CO5: The students acquire the concept of PAT systems and cost factor.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								
CO2	✓						✓				✓	
CO3	✓	✓		✓	✓							
CO4	✓		✓		✓							
CO5	✓									✓		✓

REFERENCES

1. Marguerite A.H. Ruffner, 'Energy Auditing and Conservation: Methods Measurements, management and Case Study', Hemisphere Publishing Corporation,1980.
2. Jack J. Kraushaar and Robert A. Ristenen, 'Energy and Problems of a Technical Society', Wiley, 1993.
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4. Charles M. Gottschalk, 'Industrial Energy Conservation', Wiley, 1996.
5. 'Energy Managers and Energy Auditors Guide book', Bureau of Energy Efficiency, 2006.

PW5252 OPTIMIZATION TECHNIQUES FOR ENERGY MANAGEMENT L T P C
3 1 0 4

COURSEOBJECTIVES:

- To understand the probability concepts.
- To provide knowledge on the demand analysis and forecasting techniques
- To emphasis the optimization for energy management.
- To provide knowledge about the selection of optimization techniques for real time problems and to analyze the solutions.
- To analyze and comprehend the various operating modes of different configurations at different applications.

UNIT I PROBABILITY THEORY 12

The nature of random variables: populations and samples, parameters and statistics. Probability concepts; properties of random variables, probability distribution functions.

UNIT II DEMAND ANALYSIS AND FORECASTING 12

Drivers of energy demand, Sectoral energy demand: domestic, commercial, industrial, agricultural. Projections for future demands.

UNITIII INTRODUCTION TO OPTIMIZATION 12

Problem formulation: decision variables, objective function, maxima, minima, constraints. Analysis techniques: simulation, optimization, stochastic optimization. Multiobjective optimization - non-inferior solutions, trade off analysis, weighted and constraints method.

UNIT IV LINEAR PROGRAMMING AND APPLICATION 12

Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis. Power system planning using optimization techniques, case study.

UNIT V DYNAMIC PROGRAMMING AND APPLICATION 12

Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming. Optimal energy resource, technology mix in micro and macro level energy planning exercises. Power generation expansion planning, case study.

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TOTAL: 60 PERIODS

COURSEOUTCOMES:

CO1: Ability to define and use optimization techniques and concepts.
CO2: Understand the concept of optimization methods for energy system planning
CO3: Able to define an optimization problem and exploring the solution by applying optimization methods and interpreting results.
CO4: Excel the selection of optimization techniques for real time problems and to analyze the solutions.
CO5: Analyze the various operating modes of different configurations in different applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓	✓	✓		✓							
CO3	✓	✓	✓		✓							
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓							

REFERENCES

1. Taha, H. A.,'Operations Research—An Introduction', Prentice Hall of India, New Delhi,2007.
2. Vohra, N. D.,'Quantitative Techniques in Management, III Edition', Tata McGraw-Hill Education, 2006.
3. Rardin, R. L.,'Optimization in operations research: Upper Saddle River', NJ: Prentice Hall, 1998.
4. Dhillon, J. S., and Kothari, D. P,'Power system optimization',Prentice Hall of India Private Limited, 2010.

PW5079 WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES L T P C
3 0 0 3

COURSEOBJECTIVES:

- To provide information on various methods of waste management.
- To Impart Knowledge about separation techniques & Transformation Technologies.
- To detail on the recent technologies of waste disposal
- To familiarize students with recent energy generation techniques.
- To make student realize on the importance of healthy environment.

UNIT I CHARACTERISTICS AND PERSPECTIVES 9

Sources – Types – Composition – Generation – Estimation Techniques – Characterization –Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle/ Recovery Facilities.

UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES 9

Separation & Processing: Size Reduction – Separation through Density Variation, Magnetic / Electric Field: Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies.

UNIT III WASTE DISPOSAL 9

Disposal Option & Selection Criteria - Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation - Waste Disposal: A Case Study of Bangalore.

UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION 9

Physical Transformation: Component Separation & Volume Reduction: Chemical Transformation– Combustion/Gasification/ Pyrolysi: Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion.

UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING 9

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling: Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes.

Hazardous Waste Management: Generation, Storage & Collection, Transfer & Transport, Processing, Disposal-Hazardous Waste Treatment: Physical & Chemical Treatment, Thermal Treatment, Biological Treatment - Pollution Prevention and Waste Minimization- Hazardous Wastes Management in India.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Acquired basic knowledge about the Methods of Waste Management.
CO2: Understand the concept of Segregation & Transformation Techniques.
CO3: Learned the technologies that are available for effective waste disposal along with pros / cons.
CO4: Ability to develop various Energy generation Techniques.
CO5: Able to predict the waste related problems (Hazardous Waste, Pharma Waste, Biomedical Waste etc).

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3								✓				
CO4												
CO5		✓		✓		✓	✓					✓

REFERENCES

1. George Polimveros, 'Energy Cogeneration Hand book', Industrial Press Inc, New York 1982.
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PW5074 **ENERGY STORAGE TECHNOLOGIES** **LT P C**
3 0 0 3

COURSEOBJECTIVES:

- To understand the various types of energy storage Technologies.
  - To analyze thermal storage system.
  - To analyze different battery storage technologies
  - To analyze the thermodynamics of Fuel Cell
  - To study the various applications of energy storage systems.

UNIT I INTRODUCTION **9**

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

UNIT II THERMAL STORAGE SYSTEM **9**

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

UNIT III ELECTRICAL ENERGY STORAGE **9**

Fundamental concept of batteries – measuring of battery performance, charging and is charging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, ickel – Cadmium, Zinc Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT IV FUEL CELL **9**

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantages and disadvantages –Fuel Cell Thermodynamics.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES **9**

Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Gained knowledge of various storage technologies.
CO2: Able to design a thermal storage system.
CO3: Ability to model battery storage system.
CO4: Learned to analyze the thermodynamics of fuel cell.
CO5: Gained Knowledge of various applications of storage technologies and perform the selection based on techno-economic view point.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2			✓									
CO3			✓									
CO4			✓									
CO5	✓		✓									

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', JohnWiley & Sons 2002.
2. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
3. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2012.

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PE5074 POWER QUALITY L T P C
3 0 0 3

COURSEOBJECTIVES:

- To provide knowledge about various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To equip with required skills to design conventional compensation techniquesfor power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand mitigation techniques using custom power devices such as DVR & UPQC

UNIT I INTRODUCTION 9

Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non linear loads –single phase sinusoidal, non sinusoidal source – supplying linear and nonlinear load – three phase Balance system – three phase unbalanced system – three phase unbalanced and distorted source supplying non linear loads – concept of pf – three phase three wire – three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – Dc Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified power quality conditioner.

TOTAL:45 PERIODS

COURSEOUTCOMES:

CO1 Ability to understand consequences of Power quality issues.
CO2 Ability to conduct harmonic analysis of single phase and three phase systems supplying nonlinear loads.
CO3 Ability to design passive filter for load compensation.
CO4 Ability to design active filters for load compensation.
CO5 Ability to understand the mitigation techniques using custom power devices such as

distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR)& UPQC.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓	✓					✓					
CO3	✓	✓					✓					
CO4	✓	✓					✓					
CO5	✓	✓					✓					

TEXTBOOKS:

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers,2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2ndedition)

REFERENCES:

1. Power Quality - R.C.Duggan
2. Power system harmonics –A.J.Arrillga
3. Power Electronic Converter Harmonics –Derek A.Paice

PE5251 SPECIAL ELECTRICAL MACHINES L T P C
3 0 0 3

COURSEOBJECTIVES:

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control.

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

UNIT IV STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non- linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

Attested

UNIT V OTHER SPECIAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

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TOTAL :45 PERIODS

COURSEOUTCOMES:

CO1Ability to model and analyze power electronic systems and equipment using computational software.

CO2Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.

CO3 Ability to analyse the dynamic performance of special electrical machines

CO4 Ability to understand the operation and characteristics of other special electrical machines.

CO5 Ability to design and conduct experiments towards research.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓					✓				
CO2	✓	✓	✓	✓				✓				
CO3	✓	✓	✓	✓				✓				
CO4	✓	✓	✓	✓				✓				
CO5	✓	✓										

TEXT BOOKS:

1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London,1989.
2. R.Krishnan, 'Switched Reluctance motor drives', CRC press,2001.
3. T.Kenjo, 'Stepping motors and their microprocessor controls', Oxford University press, New Delhi,2000.

REFERENCES:

1. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London,1988.
2. R.Krishnan, 'Electric motor drives', Prentice hall of India,2002.
3. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata McGraw hill publishing company, New Delhi, Third Edition,2004.
4. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition,2007.

PE5151 ANALYSIS OF ELECTRICAL MACHINES L T P C
3 1 0 4

COURSE OBJECTIVES:

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
  To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNIT I PRINCIPLES OF ELECTRO MAGNETIC ENERGY CONVERSION 12

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf– determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

UNIT II DC MACHINES 12

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – electrical and mechanical time constants - Time domain block diagrams –transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

UNIT III REFERENCE FRAME THEORY 12

Historical background of Clarke and Park transformations – power invariance and phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 12

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – modeling of multiphase machines - digital computer simulation of three phase induction machines.

UNIT V SYNCHRONOUS MACHINES 12

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – digital computer simulation of synchronous machines.

TOTAL :60 PERIODS

COURSE OUTCOMES:

CO1 Ability to optimally design magnetics required in power supplies and drive systems.
CO2 Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.
CO3 Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.
CO4 Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance
CO5 Ability to verify the results of the dynamic operation of electrical machine systems

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
1	✓	✓	✓	✓	✓							
2	✓	✓	✓	✓	✓				✓	✓		
3	✓	✓	✓	✓	✓				✓	✓		
4	✓	✓	✓	✓	✓				✓	✓		
5	✓	✓	✓	✓	✓				✓	✓		

TEXT BOOKS:

1. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. R Ramanujam,"Modelling and Analysis of Electrical Machines", I.K International Publishing Pvt. Ltd., New Delhi, 2018

Attested

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REFERENCES:

1. P S Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “ Electric Machinery”, Tata McGraw Hill, 5th Edition,199

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

Attested

REFERENCES:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.

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2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS LT P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

CO1 - Understand the costing concepts and their role in decision making
CO2 - Understand the project management concepts and their various aspects in selection
CO3 - Interpret costing concepts with project execution
CO4 - Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

Attested

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OE5095 **COMPOSITE MATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION **9**

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS **9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES **9**

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES **9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH **9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

Attested

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REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY LT P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

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.

UNITV BIO ENERGY 9

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 - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

Attested

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

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, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

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

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

Attested

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section

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CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

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

AX5092 DISASTER MANAGEMENT L T P C
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction OfEcosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, DroughtsAnd Famines, Landslides And Avalanches, Man-made disaster: Nuclear ReactorMeltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease AndEpidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

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.

Attested

UNIT V RISK ASSESSMENT6

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

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explaina critical understanding of key concepts in disaster riskreduction and humanitarian response.
CO3: Ability to illustratedisaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describean understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to developthe strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093SANSKRIT FOR TECHNICAL KNOWLEDGE **L T P C**
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS **6**

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES **6**

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS **6**

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE **6**

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING **6**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading

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

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND 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.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, 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.

UNIT VI ELECTION COMMISSION:

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

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss 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.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading

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.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX5096 PEDAGOGY STUDIES L T P C
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I 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.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III 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.

UNIT IV PROFESSIONAL DEVELOPMENT

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

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Attested

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Suggested reading

1. Ackers J, HardmanF (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.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do's and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

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

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - 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)

UNIT II

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.

UNIT III

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-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.

Attested