NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI

www.nec.edu.in

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

REGULATIONS – 2023

CURRICULUM & SYLLABUS OF

M. E. – HIGH VOLTAGE ENGINEERING

REGULATIONS 2023

CURRICULUM AND SYLLABUS

SEMESTER – I

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23HE11C	Mathematical Foundations for High Voltage Engineering	SFC	3	1	0	0	4	4
2.	23HE12C	Research Methodology and IPR	MC	2	0	0	0	2	2
3.	23HE13C	Insulation Technology	PCC	3	0	0	0	3	3
4.	23HE14C	Field Computation and Modeling of Electrical Apparatus	PCC	3	1	0	0	4	4
5.	-	Elective-I	PEC	3	0	0	0	3	3
6.	-	Audit Course-I	AC	2	0	0	0	2	2
Integrated Courses									
7.	23HE15C	High Voltage Generation and Measurement	PCC	3	0	2	0	5	4
Practical Courses									
8.	23HE16C	Field Computation Laboratory	PCC	0	0	4	0	4	2
							TOTAL	**27**	**24**

SEMESTER – II

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23HE21C	High Voltage Testing Techniques	PCC	3	0	0	0	3	3
2.	23HE22C	Electrical Transients in Power System	PCC	3	1	0	0	4	4
3.	-	Elective-II	PEC	3	0	0	0	3	3
4.	-	Elective-III	PEC	3	0	0	0	3	3
5.	-	Audit Course-II	AC	2	0	0	0	2	2
Integrated Courses									
6.	23HE23C	Insulation design of High Voltage Power Apparatus	PCC	3	0	2	0	5	4
Practical Courses									
7.	23HE24C	High Voltage Laboratory	PCC	0	0	4	0	4	2
8.	23HE25C	Mini Project with Seminar	EEC	0	0	0	4	4	2
							TOTAL	**28**	**23**

SEMESTER – III

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	-	Elective	OEC	3	0	0	0	3	3
2.	-	Elective-IV	PEC	3	0	0	0	3	3
Integrated Courses									
3.	-	Elective-V	PEC	3	0	2	0	5	4
Practical Courses									
4.	23HE31C	Project Work-I	PCC	0	0	12	0	12	6
							TOTAL	**23**	**16**

SEMESTER – IV

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Practical Courses									
1.	23HE41C	Project Work-II	PCC	0	0	24	0	24	12
							TOTAL	24	12

TOTAL CREDITS: 75

PROGRAMME ELECTIVE COURSES (Electives I to IV)

S. No	Course Code	COURSE TITLE	L	T	P	E	C
1.	23HE01E	High Voltage Equipments	3	0	0	0	3
2	23HE02E	High Voltage DC Transmission	3	0	0	0	3
3	23HE03E	Condition Monitoring of High Voltage Power Apparatus	3	0	0	0	3
4	23HE04E	EHV AC Power Transmission	3	0	0	0	3
5	23HE05E	Electromagnetic Interference and Electromagnetic Compatibility	3	0	0	0	3
6	23HE06E	Pollution Performance of Power Apparatus and Systems	3	0	0	0	3
7	23HE07E	Advanced Electromagnetic Field	3	0	0	0	3
8	23HE08E	Advanced Topics in High Voltage Engineering	3	0	0	0	3
9	23HE09E	Advances in Electric Power Transmission	3	0	0	0	3

S. No	Course Code	COURSE TITLE	L	T	P	E	C
10	23HE10E	Application of AI Techniques to High Voltage Engineering	3	0	0	0	3
11	23HE11E	Machine Learning	3	0	0	0	3
12	23HE12E	Pulse Power Engineering	3	0	0	0	3
13	23HE13E	Design of Substations	3	0	0	0	3
14	23HE14E	Flexible AC Transmission Systems	3	0	0	0	3
15	23HE15E	Power Quality	3	0	0	0	3
16	23HE16E	Restructured Power Systems	3	0	0	0	3
17	23HE17E	Power System Planning and Reliability	3	0	0	0	3
18	23HE18E	Smart Grid	3	0	0	0	3
19	23HE19E	Control of Electric Drives	3	0	0	0	3
20	23HE20E	Advanced Electrical Drives	3	0	0	0	3
21	23HE21E	Evolutionary Computing	3	0	0	0	3
22	23HE22E	Optimization Techniques to High Voltage Engineering	3	0	0	0	3
23	23HE23E	Energy management	3	0	0	0	3
24	23HE24E	Nano Dielectrics	3	0	0	0	3
25	23HE25E	Optimal control and Filtering	3	0	0	0	3
26	23HE26E	Digital Control System	3	0	0	0	3
27	23HE27E	Robotics and Industrial Automation	3	0	0	0	3
28	23HE28E	Spectroscopic Methods	3	0	0	0	3
29	23HE29E	Analytical Methods	3	0	0	0	3
30	23HE30E	Electrochemical Storage and Conversion	3	0	0	0	3

PROGRAMME ELECTIVE COURSES (Elective V)

S. No	Course Code	COURSE TITLE	L	T	P	E	C
1.	23HE31E	High Voltage Protection and Switchgear	3	0	2	0	4
2	23HE32E	Soft Computing Techniques	3	0	2	0	4
3	23HE33E	Power Electronics in Power Systems	3	0	2	0	4
4	23HE34E	Power System Operation and Control	3	0	2	0	4

OPEN ELECTIVE COURSES

S. No	Course Code	COURSE TITLE	L	T	P	E	C
1.	23GD01E	Business Analytics	3	0	0	0	3
2.	23GD02E	Industrial Safety	3	0	0	0	3
3.	23GD03E	Operations Research	3	0	0	0	3
4.	23GD04E	Cost Management of Engineering Projects	3	0	0	0	3
5.	23GD05E	Composite Materials	3	0	0	0	3
6.	23GD06E	Waste to Energy	3	0	0	0	3

AUDIT COURSES

S. No	Course Code	COURSE TITLE	L	T	P	E	C
1.	23AC01E	Technical Report Writing	2	0	0	0	0
2.	23AC02E	Disaster Management	2	0	0	0	0
3.	23AC03E	Sanskrit for Technical Knowledge	2	0	0	0	0
4.	23AC04E	Value Education	2	0	0	0	0
5.	23AC05E	Constitution of India	2	0	0	0	0
6.	23AC06E	Pedagogy Studies	2	0	0	0	0
7.	23AC07E	Stress Management by Yoga	2	0	0	0	0
8.	23AC08E	Personality Development through Life Enlightenment Skills	2	0	0	0	0

Distribution of Credit – ME HVE

Category	I Sem.	II Sem.	III Sem.	IV Sem.	Credits	Percentage of credits
SFC	4	-	-	-	04	05.33
MC	2	-	-	-	02	02.67
AC	2	2	-	-	04	05.33
PCC	13	13	-	-	26	34.67
PEC	3	6	7	-	16	21.33
OEC	-	-	3	-	03	04.00
EEC	-	2	6	12	20	26.67
Total	24	23	16	12	75	100.00

23HE11C MATHEMATICAL FOUNDATIONS FOR HIGH VOLTAGE ENGINEERING

L	T	P	E	C
3	1	0	0	4

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: apply the concepts of norm in linear equations.
CO2: learn the concepts of matrix theory.
CO3: apply the concepts of probability in distributions
CO4: interpret the characteristic features of Markovian Queues
CO5: solve Differential Equations using Numerical Methods

VECTOR AND MATRIX NORM 9+3

Vector Space - Basis – Dimensions – Inner product – Norm - Systems of Linear Equations - Solving Systems of Linear Equations - Linear Independence - Linear Mappings

ADVANCED MATRIX THEORY 9+3

Eigen values and Eigenvectors - Generalized eigen vectors - Matrix Decompositions – QR decomposition – Singular value decomposition – Pseudo inverse – Least square approximations.

RANDOM VARIABLES 9+3

Random variables – Discrete and continuous – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal Distributions.

QUEUEING MODELS 9+3

Poisson Process – Markovian queues – Single and Multi Server Models – Little formulae – Machine Interference Model – Steady State analysis – Self Service queue.

NUMERICAL METHODS 9+3

Boundary value problems for ODE – Finite difference methods – Numerical solution of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Schmidt explicit formula and Crank - Nicolson implicit scheme – Solution of wave equation.

L: 45; T: 15; TOTAL: 60 PERIODS

REFERENCES

1. Seymour Lipschutz, Marc Lipson, “Schaum's Outline of Linear Algebra”, 6th Edition, McGraw-Hill Education, 2017
2. Richard Bronson “Schaum's Outline Theory And Problem of Matrix Operations”, 2nd Edition, Tata McGraw Hill, 2018
3. Taha, H. A., “Operations Research: An Introduction”, 10th Edition, Pearson Education Edition, Asia, New Delhi, 2019.
4. Miller and Freund, “Probability and Statistics for Engineers”, 9th Edition, Pearson Education Edition, 2018.
5. John.F.Shortle, James.M.Thompson, Donald Gross and Carl M. Harris, “Fundamentals of Queueing theory”, 5th Edition, John Wiley and Sons, 2018.
6. Numerical Linear Algebra – Sundara Pandian, Prentice Hall India Learning Private Limited, Delhi, 2014

23HE12C RESEARCH METHODOLOGY AND IPR **L T P E C**
2 0 0 0 2

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Understand research problem formulation.
CO2: Analyze research related information.
CO3: Understand the research ethics.
CO4: Understand when IPR would take such important place in growth of individuals & Nation.
CO5: Recognize the importance of Report writing.

RESEARCH FORMULATION AND DESIGN **6**

Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review - primary and secondary sources, reviews, monographs, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature and research databases, development of working hypothesis – Case study

DATA COLLECTION AND ANALYSIS **6**

Method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statistical packages (SigmaSTAT, SPSS for student t-test, ANOVA, etc.), hypothesis testing – Data Mining (case studies)

RESEARCH ETHICS, IPR AND SCHOLARY PUBLISHING **6**

Ethics - ethical issues, ethical committees (human and animal); IPR- intellectual property rights and patent law, commercialization, copyright, royalty, trade related aspects of intellectual Property rights (TRIPS); scholarly publishing - IMRAD concept and design of research papers; citation and acknowledgement, plagiarism, reproducibility; and accountability

CONTEMPORARY ISSUES IN IPR **6**

Interface between IPR and Human Rights -Interface between IPR and Competition Law -IPR and sustainable development – Impact of Internet on IPR - IPR of Biological systems & E-Commerce.

INTERPRETATION AND REPORT WRITING **6**

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology-Ⅱ, RBSA Publishers, 2015
2. Kothari, C.R., Research Methodology: Methods and Techniques‖, New Age International, 2018 (Unit 1, Unit 2, Unit 5).
3. Wadehra, B.L. Law relating to patents, trademarks, copyright designs and geographical indications‖. Universal Law Publishing, Reprint, 2011. (Unit 3, Unit 4)
4. Anthony, M., Graziano, A.M. and Raulin, M.L. Research Methods: A Process of Inquiry, Allyn and Bacon 2012.
5. Carlos, C.M., Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York, 2000.

23HE13C **INSULATION TECHNOLOGY** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: summarize the different types of insulation materials and its properties.
CO 2: analyze the fundamental behavior of dielectrics in static and alternating field.
CO 3: dissect the different breakdown mechanism in gaseous dielectrics
CO 4: perceive the various breakdown mechanisms in solid and liquid dielectrics
CO 5: select the suitable insulation for HV power equipment and estimate its lifetime

INTRODUCTION **9**

Types of dielectrics and electrical insulation systems – properties of dielectric materials - gaseous, vacuum, liquid, solid and composite insulation – polymers as dielectrics - polymer structure and morphology - classification of polymers -Introduction to nano dielectrics – electrical degradation.

BEHAVIOUR OF DIELECTRICS IN STATIC AND ALTERNATING FIELD **9**

Static dielectric constant – atomic interpretation of the dielectric constant of mono-atomic gases – dependence of permittivity on various factors - polarization – types -– internal field in solids and liquids – Frequency dependence of the polarization – complex dielectric constant of non-dipolar solids – dipolar relaxation – dielectric losses.

BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS **9**

Behaviour of gaseous dielectrics in electric fields – different ionization processes - gaseous discharges –– 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 .

BREAKDOWN MECHANISMS IN SOLID AND LIQUID DIELECTRICS **9**

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 – breakdown in composite insulation.

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

LIFE ESTIMATION AND APPLICATION OF INSULATING MATERIALS **9**

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

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Adrinaus, Dekker J., "Electrical Engineering Materials", Prentice Hall of India Pvt. Ltd., New Delhi, 1979.
2. Alston L.L, "High Voltage Technology", Oxford University Press, London, 1968 (B.S. Publications, 1st Indian Edition, 2006).
3. Kuffel E., Zaengl W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2008.
4. Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", (Translated from German by Narayana Rao Y., Friedr. Vieweg & Sohn, Braunschweig), 1985.
5. Naidu M.S. and Kamaraju V., "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2013.

6. Ushakov V.Y., "Insulation of High Voltage Equipment", Springer, ISBN.3-540- 20729- 5, 2004.
7. R.E.james and Q.Su, "Condition Assessment of High Voltage Insulation in Power System Equipment", IET publications,London,U.K,2008
8. T. S.Ramu and Chakradhar Reddy, 'Reliability and Life estimation of Power Equipment", New Age International 2009.
9. Bottcher C.J.F., Theory of Electric Polarisation, Elsevier Publication, 1962.
10. Wadhwa C. L., High Voltage Engineering, Wiley Eastern Limited, NewDelhi,1994
11. Mann N.R. Schafer R.E. and Singpurwalla N.D., Methods of Statistical Analysis and Life Data, John Wiley and Sons, New York, 1974.
12. B. Tareev, "Physics of Dielectric Materials", Mir Publishers Moscow, 1979

23HE14C FIELD COMPUTATION AND MODELING OF ELECTRICAL APPARATUS

L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: recall the basic concepts in electric and magnetic fields. (K2)
CO2: choose the new techniques to find the solutions of electrostatic boundary value problems.(K2)
CO3: improve the new techniques to achieve the accurate results.(K2)
CO 4: determine and find the various parameters of field configurations. (K2)
CO5: model the various electrical apparatus.(K2)

ELECTRIC & MAGNETIC FIELD – INTRODUCTION 9

Electric field–Coulombs law–Gauss Law–Electric Dipole-Electric fields in material space Polarization–Magnetic field–Amperes Law–Faradays Law–Maxwell's equation- principle of energy conversion.

SOLUTIONS OF FIELD EQUATIONS– ANALYTICAL METHODS 9

Limitations of the conventional design procedure need for the field analysis based design - Problem definition and solution by analytical methods - Direct integration method - Method of images

SOLUTIONS OF FIELD EQUATIONS–NUMERICAL METHODS 9

Field Plotting –Finite element method (FEM)–Stiffness matrix- shape functions- Finite Difference Method (FDM)–Moment method

FIELD COMPUTATION FOR BASIC CONFIGURATION 9

Computation of electric and magnetic field intensities – Capacitance and Inductance – Force, Torque, and Energy for basic configurations – skin effect.

DESIGN APPLICATIONS 9

Resistive and capacitive field computation-Electromagnetic modelling of Insulators Bushings, Transformers –Rotating machines for power frequency and impulse voltages.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Mathew Sadiku,"Elements of Electromagnetics", Oxford University Press,6th Edition,2015.
2. Sivaji Chakravorti, "Electric Field Analysis", CRC Press (Taylor & Francis), USA, 2015.
3. NathanIda, JoaoP .A .Bastos, "Electromagnetics and calculation of fields", Springer Verlage, 2nd Edition, 2002.
4. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
5. S.J Salon, "Finite Element Analysis of Electrical Machines."Kluwer Academic Publishers, London, 1995 (distributed by TBH Publishers & Distributors, Chennai, India).
6. User manuals of MAGNET, MAXWELL& ANSYS software.
7. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 3rd Edition, 1996.
8. William Hayt, "Engineering Electromagnetics" Tata Mc Graw-Hill Edition, 2012.

23HE15C HIGH VOLTAGE GENERATION AND MEASUREMENT L T P E C
3 0 2 0 4

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: explain the need for the generation of high AC, DC Voltage. (K2)
CO2: describe the principles behind generation of impulse voltages and current. (K2)
CO3: understand the principle of high AC voltage and current measurement systems (K2)
CO4: explain the measurement techniques of high DC voltage and current.(K2)
CO5: outline the application areas of high voltage engineering. (K2)
CO6: Demonstrate the generation methods of high DC (K2)
CO7: Demonstrate the generation methods of high AC (K2)
CO8: Demonstrate the generation methods of high Impulse voltages. (K2)
CO9: Measurement methods of high AC, DC and impulse voltages. (K2)
CO10: Describe the simulation of lightning and switching impulse currents (K2)

GENERATION OF HIGH DC VOLTAGES 9 + 6

Theory:

Need for generating high voltages – Requirements of HV generation in laboratory-Role of the insulation in power apparatus and systems- Generation of DC Voltages- Rectifier circuits- cascade circuits- Voltage Multiplier Circuits- Cockcroft Walton circuit- voltage regulation- electrostatic generators.

Practice:

Generation of HVDC with different sphere gap spacing

GENERATION OF HIGH AC VOLTAGES 9 + 6

Theory:

Testing transformer- Single unit testing transformer- cascaded transformer- equivalent circuit of cascaded transformer- resonant circuits- resonant transformer- voltage regulation.

Practice:

Generation of HVAC with different sphere gap spacings

GENERATION OF IMPULSE VOLTAGES 9 + 6

Theory:

Impulse voltage: lightning impulses, switching Impulses- generator circuit – Marx generator – analysis of single stage and multistage circuits-wave shaping- modeling of impulse generator circuit-triggering and control of impulse generators - generation of switching surge voltage and currents- generation of non- standard impulse voltages and very fast transient voltage (VFTO)- generation of impulse current.

Practice:

Generation of Impulse Voltage with various gap spacing and Positive and Negative Polarity

MEASUREMENTS OF HIGH VOLTAGES **9 + 6**

Theory:

Measurement of high DC voltages: Sphere gaps, factors affecting sphere gap measurements, correction factors- Measurement of high AC voltage: Capacitance voltage dividers, Chubb-Fortescue method, CVT, electrostatic voltmeters- Measurement of Impulse voltages – fast digital transient recorders for impulse measurement - high AC current: resistive shunts- electromagnetic current transformer-Relevant IS and IEC Standards.

Practice:

Measurement of breakdown strength of air medium with high AC voltage under uniform and non uniform field Measurement of switching impulse voltage

GENERATION AND MEASUREMENTS OF IMPULSE CURRENTS **9 + 6**

Theory:

Generation of impulse currents, conversion of impulse voltage generator to impulse current generator- Measurement of high AC,DC and Impulse currents- Resistive shunts- Resistive shunts- Magnetic links -Hall effect generators-magneto-optical method and current transformers.

Practice:

Simulation of Lightning and Switching Impulse

L: 45; P: 30; TOTAL: 75 PERIODS

REFERENCES

1. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2nd Edition, 2008
2. Dieter Kind, Kurt Feser, “High Voltage Test Techniques”, Newnes, 2nd Edition, 2001.
3. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-hill Publishing Company Ltd., 5th Edition, New Delhi, 2020.
4. Gallagher, T.J., and Permain, A., “High Voltage Measurement, Testing and Design”, John Wiley Sons, New York, 1984.
5. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, RoshdyRadwan, “High Voltage Engineering Theory and Practice” 2nd 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.

23HE16C **FIELD COMPUTATION LABORATORY** **L T P E C**
0 0 4 0 2

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: interpret the field distribution model of insulating/dielectric medium.(K2)

CO2: analyze the generation of transient and over voltages using simulation tool.(K2)

LIST OF EXPERIMENTS

1. Electrostatic Analysis of Single and multiple dielectric capacitance model using FEM
2. Modelling of high voltage porcelain insulator with and without contamination layer using FEM
3. Modelling of high Voltage Transformer using FEM
4. Modelling of high voltage glass insulator with and without contamination layer using FEM
5. Modelling of solid dielectric material with different size of void and position using FEM
6. Simulation of Lightning and Switching Impulse voltage generator
7. Simulation of RL,RC and RLC-DC transient circuit
8. FEM Simulation of different electrode configurations

P: 60; TOTAL: 60 PERIODS

23HE21C HIGH VOLTAGE TESTING TECHNIQUES L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO 1: explain different types of testing and measurement techniques.
CO 2: Interpret the life time analysis data and statistical evaluation of measured results
CO 3: Experiment with different test procedures for HV power apparatus as per standards.
CO 4: explain non-destructive insulation test for assessing insulation characteristics
CO 5: Execution of artificial pollution test and design different types of HV laboratory

INTRODUCTION **9**

Objectives of high voltage testing - classification of testing methods- indoor and outdoor insulations - self restoration and non-self restoration systems-standards and specifications, measurement techniques, Diagnostic testing, online measurement – influence and correction of ambient condition.

STATISTICAL EVALUTION OF MEASURED RESULTS **9**

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

TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT **9**

Testing of insulators, bushings, surge arresters, power transformer, cables - testing methodology: various type tests, sample tests, routine tests - recording of oscillograms - interpretation of test results.

NON-DESTRUCTIVE INSULATION TEST TECHNIQUES **9**

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.

POLLUTION TESTS AND DESIGN OF HIGH VOLTAGE LAB **9**

Artificial Pollution tests- salt-fog method, solid layer method, Dimensions of High voltage

laboratory, equipment- fencing, earthing and shielding.

L: 45; TOTAL: 45 PERIODS

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., New Delhi, 2004.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, 2005
4. Gallagher, T.J., and Pearmain A., “High Voltage Measurements, Testing and Design”, John Willey & Sons, New York, 1983.
5. IS, IEC and IEEE standards for “Dielectric Testing of High Voltage Apparatus”, 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.
6. Nelson W., “Applied Life Data Analysis”, John Wiley and Sons, New York, 1982.
7. IEC – 60270, “HV Test technique – Partial Discharge Mechanism”, 3rd Edition, December 2000.

23HE22C ELECTRICAL TRANSIENTS IN POWER SYSTEM

L	T	P	E	C
3	0	0	0	3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: understand travelling wave propagation on transmission lines. (K2)
CO 2: describe the transient effects in power networks and components (K2)
CO 3: explain the source and characteristics of lightning, switching, and temporary over voltages. (K2)
CO 4: describe the EMI issues related to high voltage engineering (K2)
CO 5: select various protective devices and insulation level. (K2)

TRAVELLING WAVES ON TRANSMISSION LINE **9**

Circuits with Lumped and Distributed Parameters– Wave Equation – Reflection, Refraction, Behavior of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave.

COMPUTATION OF POWER SYSTEM TRANSIENTS **9**

Principle of digital computation – Matrix method of solution- Modal analysis- Z transform, Modelling for computation of electromagnetic transients-MNA Program -wavelet technique for determining fault in transformer.

LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES **9**

Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Influence of tower footing and earth Resistance- Protection by ground wires- Switching over voltages: Energizing transients - closing and re-closing of lines –Switching of cables and capacitor banks, Short line or kilometric fault, - Very Fast Transient Overvoltage (VFTO) -Temporary overvoltages: line dropping, load rejection, over voltages induced by fault, Ferranti effect, Ferromagnetic resonance.

BEHAVIOUR OF EQUIPMENTS UNDER TRANSIENT CONDITION **9**

Initial and Final voltage distribution – Winding oscillation – Traveling wave solution – Behavior of the transformer core under surge condition – Rotating machine – Surge in generator and motor – Surge Arrestors.

INSULATION CO-ORDINATION **9**

Definitions, Principle of insulation coordination, Volt-time curves-Rated withstand voltage levels and clearances, relevant standard-Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – Insulation level – Statistical approach – Coordination between insulation and protection level –Overvoltage protective device.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991.
2. Juan A. Matinez-velasco, “Power system Transients- Parameter determination”, CRC press, 2010
3. Philip C. Magnusson, Gerald C. Alexander, Vijai K Tripathi, Andreas Weisshaar, “Transmission lines and wave propagation”, CRC press, 2001.
4. Arieh L. Shenkman, “Transient analysis of Electric power circuits Handbook”, Springer, 2005.
5. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., 1996.
6. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
7. Working Group 33/13-09, “Very fast transient phenomena associated with Gas Insulated System”, CIGRE, 33-13, pp. 1-20, 1988.

23HE23C INSULATION DESIGN OF HIGH VOLTAGE POWER APPARATUS **L T P E C**
3 0 2 0 4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: summarize the different types of insulation materials and its properties.
CO 2: analyze the fundamental behavior of dielectrics in static and alternating field.
CO 3: dissect the different breakdown mechanism in gaseous dielectrics
CO 4: perceive the various breakdown mechanisms in solid and liquid dielectrics
CO 5: select the suitable insulation for HV power equipment and estimate its lifetime
CO 6: understand the conditions of different dielectrics using non-destructive test techniques.
CO 7: infer the quality of high voltage insulators and cables
CO 8: estimate the performance of liquid dielectric medium

INTRODUCTION **9 + 6**

Theory: Electric field distribution and breakdown strength of insulating materials, factors affecting breakdown strength- uniform and non uniform fields- symmetrical and asymmetrical electrode configurations-fields in single and multi dielectric materials- dielectric refraction: transverse, longitudinal and inclined boundary conditions- electric stress control methods.

Practice: 1. Breakdown strength of solid, liquid and Gas insulating medium.

2. Electric field distribution in single and multi dielectric materials using simulation tool.

HV INSULATORS AND BUSHING **9 + 6**

Theory: Types of insulators- properties- materials- applications- limitations- pollution flashover mechanism- levels of pollution- mitigation techniques- profile selection with respect to environmental conditions- Relevant standards for design- Bushing types- field control methods- design methodology- applications.

Practice: 1.Determination of 50% critical impulse flash over voltages on 11 kV insulator and Bushing with Positiveand Negative Polarity.

POWER TRANSFORMER **9 + 6**

Theory: Insulation schemes- types of windings-calculation of winding capacitance and inductance- surge phenomenon- voltage distribution- stress control methods- insulating materials-transformer insulation- Effects of Environmental Factors in Transformer's Insulation Life.

Practice: stress control methods for different types of windings in transformer

CABLES **9 + 6**

Theory: Types of cables- materials used- cable constants- stress-losses- DC and sub sea cables- partial discharge in cable- treeing- ageing- life estimation- grading - Criteria influencing the selection and design of HV

Practice: 1. Measurement of Partial Discharge in cable
2. Power frequency test in cable
3. Design of cable joints (capacitive grading)

SURGE ARRESTER **9 + 6**

Theory: Types of arresters- V-I characteristics of SiC and ZnO- design of lightning arrester based on housing materials- supporting structure – modelling of arrester- voltage distribution along the arrester-insulation coordination.

Practice: 1. Study of insulation coordination in surge arresters with grading ring.

L: 45; P: 30; TOTAL: 75 PERIODS

REFERENCES

1. Dieter Kind and Hermann Karner, “High Voltage Insulation Technology”, (Translated from German by Narayana Rao Y., Friedr. Vieweg & Sohn, Braun schweig), 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. Alston, L.L, “High Voltage Technology”, Oxford University Press, London 1968.
5. Karsai, K.Kerenyi, D. and Kiss. L., “Large Power Transformers”, Elsevier, Armsterdam, 1987.
6. Feinberg, R., “Modern Power Transformer Practice”, the Macmillan Press Ltd., New York, 1979.
7. Looms, J.S.T, “Insulators for High Voltages”, IET, London, U.K, 1988.
8. IEC 60815 Part 1,2,and 3 (2014), “Selection and Dimensioning of Polluted Insulators”

23HE24C	**HIGH VOLTAGE LABORATORY**	**L T P E C** **0 0 4 0 2**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: infer the conditions of different insulating material using various non-destructive test techniques. (K2)

CO2: interpret the quality of high voltage insulators and cables. (K2)

CO 3: evaluate the performance of liquid dielectric medium. (K2)

LIST OF EXPERIMENTS

1. Study of AC, DC and LI breakdown voltage of air under uniform and Non- Uniform electrode configurations
2. Measurement of Viscosity of liquid dielectrics
3. Measurement of pH
4. Measurement of Conductivity of samples
5. Study of impulse voltage breakdown characteristics of air under different pressures.
6. Measurement of Partial Discharge in dielectric using Partial Discharge Meter
7. Dielectric withstand tests on Various types of Insulator (dry and wet condition)
8. Dielectric withstand tests on Bushing (dry and wet condition)
9. Design of insulator with grading and corona rings
10. Design of condenser and non-condenser bushing
11. Electric field in homogeneous and non-homogeneous materials i. Symmetrical and asymmetrical electrode configurations ii. Parallel plate, coaxial cable and concentric spheres
12. Critical Flashover of a Sphere Gap using IVG (Virtual Lab)

P: 60; TOTAL: 60 PERIODS

Estd : 1984

R-2023 M.E. HVE

PROGRAMME ELECTIVE COURSES

Estd : 1984

23HE01E HIGH VOLTAGE EQUIPMENTS L T P E C
3 0 0 0 3

COURSEOUTCOMES

Upon completion of this course, the students will be able to

CO1: outline the basic concepts of circuit breakers (K2)
CO2: inspect the behavior of HV Power Transformer (K2)
CO3: identify the appropriate bushing techniques for high voltage applications (K2)
CO4: illustrate the basic concepts of different types of cables and protection devices (K2)
CO5: appraise the theory of Gas Insulated Substation(K2)

HIGH VOLTAGECIRCUITBREAKERS 9

Arc interruption concept – Circuit making and breaking – Types – Air break, SF6 and vacuum circuit breakers.

HIGH VOLTAGE POWER TRANSFORMER 9

Transformer insulation requirements – Dielectric strength and voltage conditions – Winding arrangements – Surge behavior – Behavior of liquid dielectric – Electrode surface phenomena –Gas evolution–Processing techniques–Construction of EHV transformer–Short circuit behavior.

HIGH VOLTAGE BUSHINGS 9

Types – Non-condenser bushing – Condenser bushing – Bushing application for different equipments like Alternator, transformer, switchgear, wall bushing – Design of bushing and testing procedures.

HIGHVOLTAGE CABLESANDHIGH PROTECTIONDEVICES 9

Different types of cables – Paper insulated cables – XLPE cables – Gas-filled cables – Types, Working and applications of Insulators, Surge Diverter, Lighting Arrester, Disconnect switches.

GAS INSULATED SUBSTATION (GIS) 9

Comparison of GIS and air insulated substations — Design and layout of GIS — Description of various components of GIS-Advantages of GIS.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Anthony J. Pansini, “Electrical Transformers and Power Equipment”, 3rd Edition, Prentice Hall Publications, 1999.
2. Ruben D.Garzon, “High Voltage Circuit Breakers: Design and Applications”, 2nd Edition, Taylor and Francis Publications, 2005.
3. Nakanishi, “Switching Phenomena in High-Voltage Circuit Breakers”, Marcel Dekker Inc, 1991.
4. M.S.Naidu, “Gas Insulated Substations”, L.K. International Publishing House Pvt. Ltd, 2008.
5. Colin Bayliss, Colin R. Bayliss, Brian J. Hardy, “Transmission and Distribution Electrical Engineering”, Elsevier Ltd., 2012

23HE02E HIGH VOLTAGE DC TRANSMISSION L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: Demonstrate the knowledge of different types of HVDC transmission system (K2)

CO 2: Discuss the operation of HVDC converters (K2)
CO 3: Describe about HVDC control and its operation (K2)
CO 4: Knowledge about filters and protection strategies in HVDC (K2)
CO 5: Explain Recent trends in HVDC transmission and its application (K2)

INTRODUCTION **9**

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - Economic, technical and reliability, limitations, Types of HVDC links - monopolar, bipolar and homopolar links, Components of HVDC transmission system.

ANALYSIS OF HVDC CONVERTERS **9**

Rectifier and Inverter operation of Graetz circuit without and with overlap. Output voltage waveforms and DC voltage in both rectifier and inverter operation, Equivalent circuit of HVDC link
.

HVDC SYSTEM CONTROL **9**

Basic means of HVDC system control, desired features, power reversal, Basic controllers - constant ignition angle, constant current and constant extinction/ advance angle control, power control, high level controllers. Converter maloperations - misfire, arc through, commutation failure.

HARMONICS **9**

Harmonics in HVDC system - Characteristic and uncharacteristic harmonics - Troubles due to harmonics – Harmonic filters - Active and passive filters - Reactive power control of converters, Protection issues in HVDC, over voltage and over current protection Voltage and current oscillations, DC reactor design, DC Circuit breakers.

RECENT TRENDS IN HVDC TRANSMISSION **9**

CSC based HVDC system, VSC based HVDC system – Multi- terminal HVDC systems and HVDC system applications in wind power generation, Interaction between AC and DC systems

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Kimbark, E.W., “Direct Current Transmission - Vol.1”, Wiley Inter science, New York, 1971.
2. Padiyar, K.R., “HVDC transmission systems”, Wiley Eastern Ltd., 2010.
3. Kamakshaiah, S and Kamaraju, V, „HVDC Transmission‟, 1st Edition, Tata McGraw Hill Education (India), New delhi 2011.
4. Arrilaga, J., “High Voltage Direct Current Transmission‟, 2nd Edition, Institution of Engineering and Technology, London, 1998.
5. Vijay K.Sood, “HVDC and FACTS Controllers”, Kluwer Academic Publishers, New York, 2004.

23HE03E CONDITION MONITORING OF HIGH VOLTAGE POWER APPARATUS

L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: describe the concept of condition monitoring of high voltage apparatus. (K2)
CO 2: explain different types of faults and its monitoring methods of power transformer. (K2)
CO 3: apply the diagnostic techniques for various power generation faults for rotating electrical machines. (K3)

CO 4: employ the idea of various diagnostic techniques and condition monitoring. (K2)
CO 5: Summarize the insulation materials in application area and various testing techniques. (K2)

INTRODUCTION **9**

Importance and necessity of maintenance-Breakdown maintenance, planned maintenance and condition based maintenance- Concept of condition monitoring of electrical equipments. Overview of Advanced tools and techniques of condition monitoring- General issues of condition monitoring – Main Components in a condition monitoring system.

CONDITION MONITORING OF TRANSFORMER **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 – FR.

CONDITION MONITORING OF ROTATING ELECTRICAL MACHINES **9**

Power generation faults and monitoring methods - Motor Current Signature Analysis (MCSA) -Air-Gap Eccentricity, Broken Rotor Bars, Bearings Damage, Shorted Turns in Stator Windings-Monitoring of rotating elements - Overall level monitoring - Frequency spectrum monitoring.

INSULATION MATERIALS AND MONITORING **9**

Outdoor insulation: Materials, ageing, diagnostic, polymeric materials, and semi-conducting, ceramic glazes - Insulation degradation detection, Particulate detection: core monitors, chemical analysis, Gas analysis off-line, Gas analysis on-line, Lubrication oil and bearing degradation.

FUTURE TRENDS **9**

Reaming life analysis, Condition based maintenance and asset management, applications of Artificial Intelligence techniques in monitoring, latest methodologies and Future trends.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. W. H. Tang and Q. H. Wu, “Condition Monitoring and Assessment of Power Transformers Using computation Intelligence”, Springer, London 2010
2. Peter Tavner, Li Ran, Jim Penmanand Howard Sedding, “Condition Monitoring of Rotating Electrical Machines”, Published by The Institution of Engineering and Technology, London, United Kingdom, 2008.
3. Hamid A Toliyat, Subhasis Nandi, Seungdeog Choi, Homayoun Meshgin-Kelk, “Electric Machines: Modeling, Condition Monitoring and Fault Diagnostics”,, CRC Press.
4. Chakravorti Sivaji, Dey Debangshu, Chatterjee Biswendu, “Recent Trends in the Condition Monitoring of Transformers- Theory, Implementation and Analysis” Springer, 2013
5. Greg C. Stone, Edward A. Boulter, Ian Culbert, Hussein Dhirani, “Electrical Insulation for Rotating Machines: Design, Evaluation, Aging, Testing, and Repair”, IEEE Press Series on Power Engineering, A John Wiley & Sons, Inc., Publication, 2004
6. R.E. James and Q. Su, “Condition Assessment of High Voltage Insulation in Power System Equipment”, Published by The Institution of Engineering and Technology, London, United Kingdom, 2008

23HE04E **EHV AC POWER TRANSMISSION** **L T P E C**

3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: explain the role of EHVAC Transmission and Mechanical considerations. (K2)
CO 2: calculate the line parameters for multi-conductor lines. (K2)
CO 3: estimate the voltage gradients of conductors. (K2)
CO 4: discuss the concepts of corona and radio interference. (K2)
CO 5: illustrate the effect of electrostatic field on humans and vehicles. (K2)

INTRODUCTION **9**

Line trends and preliminary aspects – Standard transmission voltages – Power handling capacities and line losses – Mechanical aspects.

CALCULATION OF LINE PARAMETERS **9**

Calculation of resistance, inductance, and capacitance for multiconductor lines – Calculation of sequence inductances and capacitances – Line parameters for different modes of propagation - Resistance and inductance of ground return.

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.

CORONA EFFECTS **9**

Power losses and audible losses: I2R loss and corona loss – Corona loss formula- charge voltage diagram and corona loss - Corona pulse generation and properties – Limits for radio interference fields.

ELECTROSTATIC FIELD 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 – Electrostatic induction in un-energized circuit of a D/C line – Induced voltages in insulated ground wires.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Pvt. Ltd., 2nd Edition, 2011.
2. Power Engineer‟s Handbook, TNEB Engineers Association, Revised and Enlarged 6th Edition, October 2002.
3. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com)

23HE05E ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY **L T P E C 3 0 0 0 3**

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: describe the basic concepts and characteristics and design of electromagnetic compatibility (k2)

CO2: discuss the methods of grounding and cabling (k2)
CO3: summarize balancing, filtering and shielding (k2)
CO4: explain the EMI issues related to high voltage elements and circuits (k2)
CO5: appraise the EMI standard and regulations (k1)

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.

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.

BALANCING, FILTERING AND SHIELDING **9**

Power supply decoupling – Decoupling filters – Amplifier filtering – High frequency filtering shielding — near and far fields — Shielding effectiveness — Absorption and reflection loss — Shielding with magnetic material – Conductive gaskets – Windows and coatings – Grounding of shields.

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.

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

L: 45; TOTAL: 45 PERIODS

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.
4. Bridges, J.E Milleta J. and Ricketts.L.W., “EMP Radiation and Protective techniques”, John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, “Series on Electromagnetic Interference and Compatibility”, Vol.
6. Weston David A., “Electromagnetic Compatibility, Principles and Applications”, 1991

23HE06E POLLUTION PERFORMANCE OF POWER APPARATUS AND SYSTEMS

L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: enlighten the Mechanism of pollution flashover, Analytical determination. (K2)
CO2: explain the artificial pollution testing methods. (K2)
CO 3: discuss the pollution performance of insulators. (K2)
CO 4: illustrate the pollution performance of surge diverters. (K2)
CO 5: describe the pollution performance of indoor equipments.(K2)

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.

POLLUTION TESTING **9**

Artificial pollution testing – Salt-fog method – Solid layer method – Monitoring of parameters – Measurement of layer conductivity – Field testing methods.

POLLUTION PERFORMANCE OF INSULATORS **9**

Ceramic and non-ceramic insulators – Influence of Profile on the Pollution Performance– Rib factor effect in AC and DC insulators – Various techniques to improve the performance of insulators – Properties of material used for insulators modeling under various polluted conditions.

POLLUTION PERFORMANCE OF SURGE DIVERTERS **9**

External insulation — Effect of pollution on the protective characteristics of gap and gapless arresters — Weather ageing test (salt fog) for surge arresters- Modeling of surge diverters under polluted conditions.

POLLUTION PERFORMANCE OF INDOOR EQUIPMENT **9**

Condensation and Contamination of indoor switch gear – Tracking and erosion of indoor equipment - Performance of organic insulator under polluted conditions – Accelerated testing techniques- Assessment of Environmental and System Stresses.

L: 45; TOTAL: 45 PERIODS

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.
4. Dieter Kind and Kurt Feser, “High Voltage Test Techniques”, SBA Electrical Engineering Series, New Delhi, 2nd Edition, 1999.
5. Looms, J.S.T., “Insulators for High Voltages”, Peter Peregrinus Ltd., London, 1988.
6. Working Group D1.44, “Pollution test of naturally and artificially contaminated insulators” Cigre 2017

23HE07E ADVANCED ELECTROMAGNETIC FIELDS L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: explain the basic concepts in electrostatics.
CO 2: illustrate the concepts of electric fields and space charge free fields.
CO 3: differentiate the techniques used for analyzing the electric fields.
CO 4: analyze the electric fields with combination of different computation techniques.
CO 5: estimate the electric fields behavior in conductors and dielectrics.

BASICS OF ELECTROSTATICS 9

Electrostatic Fields – Coulombs Law – Electric Field Intensity (EFI) – EFI due to a line and a surface charge – Work done in moving a point charge in an electrostatic field – Electric Potential – Properties of potential function – Potential gradient – Gauss's law – Application of Gauss's Law – Maxwell's first law – Laplace's and Poisson's equations – Solution of Laplace's equation in one variable.

ELECTRIC FIELDS ANALYSIS 9

Introduction – Analytical calculation of space charge free fields – Simple geometries – Transmission conductors to ground – Fields in multi dielectric media – Experimental analogs for space charge free fields – Electrolytic tank – Semi conducting paper analog – Resistive mesh analog.

NUMERICAL METHODS FOR FIELD CALCULATION 9

Numerical computation of space charge free fields – Successive imaging technique – The dipole method - charge-simulation technique – Finite-difference technique – Combined charge simulation and finite difference technique – Finite element technique – Combined charge simulation and finite element technique – Boundary element method – Integral equations technique – Montecarlo technique.

ANALYTICAL METHODS FOR FIELD CALCULATION 9

Analytical calculations of fields with space charges – Numerical computation of fields with space charges finite element technique – Finite element technique combined with the method of characteristics – Charge simulation technique combined with the method of residues – Electric stress control and optimization.

CONDUCTORS & DIELECTRICS 9

Behavior of conductors in an electric field – Conductors and insulators – Electric field inside a dielectric material – Polarization – Dielectric – Conductor and dielectric – Dielectric boundary conditions – Energy stored and energy density in a static electric field – Current density – Conduction and convection current densities – Ohm's law in point form – Equation of continuity.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. William H. Hayt and John. A. Buck, "Engineering Electromagnetics", Tata Mc-Graw Hill Companies, 7th Edition, 2012.
2. John Kraus and Daniel Fleisch , "Electromagnetics with Applications", McGraw-Hill Inc., 5th Edition, 2017.
3. Gangadhar, "Field Theory", Khanna Publishers, 2002.

4. Matthew N.O. Sadiku and S.V.Kulkarni, “Principles of Electromagnetics”, Oxford University Press, 6th Edition, 2015.
5. Paul C.R. and Nasar S.A., “Introduction to E-Magnetics”, Tata McGraw-Hill Publications, 2005.

23HE08E ADVANCED TOPICS IN HIGH VOLTAGE ENGINEERING L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: Summarize the measurement and diagnostic technologies in HV measurement
CO 2: Employ SF_6 insulation and monitoring system
CO 3: Interpret the safety and earthing requirements for HV system.
CO 4: Explain pulsed electric field and its applications
CO 5: Summarize the role of Pulsed electric field technology in food and medical Industry.

MEASUREMENT AND DIAGNOSTIC TECHNOLOGIES 9

Introduction – Digital Impulse Recorders – Digital Techniques in HV tests – Testing automation – Fundamental optical principles - Electro-optic Sensors- Magneto-optic Sensors – Measurement of very fast transients in GIS –- Space charge measurement techniques – Electro-optical image techniques

SF6 INSULATION SYSTEMS AND THEIR MONITORING 9

Introduction – Ionisation phenomena -Breakdown mechanisms in low divergence fields-Nonuniform field breakdown in SF_6- Breakdown in GIS-Possible improvements in SF_6 insulation-Partial discharge diagnostic techniques for GIS- Application of UHF technique to PD detection in GIS

REQUIREMENTS OF EARTHING AND SAFETY 9

Introduction – Nature of static electricity – Triboelectric series – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Equipment Earthing, Neutral Point Earthing, Substation Earthing System, Dimensioning of Earth Conductors, Step Potential and Touch Potential, Earth Mat, Resistance of Earthing System, Values of Soil Resistivity, Fencing, Procedure of Laying Earthing

PULSED ELECTRIC FIELDS 9

Introduction – Definitions- Mechanisms of microbial inactivation’s – Electrical breakdown – Electroporation – Inactivation models – Critical factors analysis of process, product and microbialfactors – Pulse generators and treatment chamber design – Research needs.

PULSED POWER APPLICATIONS 9

Introduction - Ion beam materials treatment -Air treatment and pollution control - Pulsed corona precipitators - Biological applications - Food processing: Processing of juices, milk, egg, meat and fish-Water purification Medical applications -Ultra wideband and HPM applications - X-ray simulators.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Haddad, D. Warne, “Advances in High Voltage Engineering” published by The institution of Engineering and Technology, London, United Kingdom, 2007.
2. Malik N.H., Ai-Arainy A.A., Qureshi M.I., “Electrical Insulation in Power Systems”, Marcel Dekker, Inc., 1998.
3. Mazen Abdel-Salam, Hussien Anis, Ahdab EI-Morshedy, “High Voltage Engineering”, Theory

and Practice, Marcel Dekker Inc., 2nd Edition, 2000.
4. Barbosa-Canovas G.V., "Pulsed electric fields in food processing: Fundamental aspects and applications" CRC Publisher Edition, March 1st, 2001.
5. Lelieveld H.L.M., Notermans S., et al, "Food preservation by pulsed electric fields: From research to application", Woodhead Publishing Ltd, October 2007.

23HE09E ADVANCES IN ELECTRIC POWER TRANSMISSION L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: discuss the recent development in transmission system
CO 2: explain the design considerations in transmission system
CO 3: illustrate the function of insulators for outdoor environments.
CO 4: summarize the design considerations of substation
CO 5: Interpret the function of Gas insulated Substation (GIS)

INTRODUCTION 9

Overview of primary and renewable energy sources, installed capacity and projected growth. Recent advances in UHV power transmission - introduction to 765/1200kV AC and ±500/800 kV DC transmission systems; present status and future growth

DESIGN CONSIDERATION IN OVERHEAD TRANSMISSION LINES 9

Design criteria for overhead transmission lines: general system design, methodology, and reliability, wind/ice loading, security and safety requirements. Components of HV transmission systems, types of conductors/HTLS, bundle configurations, conductor accessories/clamps etc. Transmission towers: calculations of clearances for power frequency, switching and lightning surges, right of way (ROW), earth wire/OPGW.

INSULATORS FOR OUTDOOR APPLICATIONS 9

Introduction – role of insulators and material properties, Examples of design, Flashover mechanisms – electrical characteristics under natural and polluted conditions, -Selection of insulators for light, medium and heavy polluted areas, performance under laboratory aging, normal and low temperatures- hybrid insulators.

DESIGN CONSIDERATION IN SUBSTSTIONS 9

Up-gradation of existing transmission lines, Design considerations of UHV Substations, AIS, Hybrid-AIS - Review on insulation coordination/overvoltages for UHV systems- high performance metal oxide surge arresters, Introduction to SCADA and Substation automation- Earthing and safety measures for 765/1200kV HV substations.

GAS INSULATED SUBSTSTIONS 9

Evolution of GIS, Basics of GIS technology, Key design features,SF6 volume reduction, Reliability of GIS, Design tests, Gas tightness and monitoring, Contaminants and oxidation in gas, conductors in GIS system, components in GIS, testing and installation, Global status of GIS

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Haddad, D. Warne, "Advances in High Voltage Engineering" published by The institution of Engineering and Technology, London, United Kingdom, 2007.
2. Hermann Koch, "Gas Insulated Substations", Wiley, 2014.
3. R.D.Begamudre, "Extra High Voltage AC Transmission Engineering", 4th Edition, New

Academic Science Ltd, 2011.
4. J.S.T. Looms, “Insulators for High Voltages”, IET Power and Energy Series, Volume 7, 2006.
5. CIGRE Working Group SC B.3-22 “Technical requirements for substations exceeding 800 kV”, Brochure No: 400, Dec 2009.
6. IEC-60826, International standard, “Design criteria of overhead transmission lines”, 2003.

23HE10E APPLICATION OF AI TECHNIQUES TO HIGH VOLTAGE ENGINEERING **L T P E C 3 0 0 0 3**

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Demonstrates the basic foundations of machine and deep learning algorithms

CO2: Apply appropriate deep learning neural network architectures for partial discharge signal de-noising

CO3: Develop a support vector classifier model for fault recognition in high voltage transformer

CO4: Construct a Deep Neural Network algorithm for Imbalanced dataset for Classification of faults In High high-voltage cable

CO5: Apply optimization techniques to tune the hyperparameters in deep neural network

DEMONSTRATES THE BASIC FOUNDATIONS OF MACHINE AND DEEP LEARNING ALGORITHMS **9**

Artificial Intelligence – Supervised Learning – Unsupervised Learning – Semi-Supervised Learning – Reinforcement Learning - Machine Learning –Deep Learning – Ensemble Learning - Estimating Generalization Errors – Metrics for assessing regression – Metrics for assessing classification – classification problem with imbalance dataset – cost sensitive classification metrics.

APPLY APPROPRIATE DEEP LEARNING NEURAL NETWORK ARCHITECTURES FOR PARTIAL DISCHARGE SIGNAL DE-NOISING **9**

Introduction – Neuron models – Network architectures –weights learning for a linear processing unit – multi-layer perceptron networks – Signal processing – NARX network – LSTM Network – Adversarial de-nosier model – Partial discharge signal measurement – signal de-noising – evaluated parameters – Hyperparameters tuning

DEVELOP A SUPPORT VECTOR CLASSIFIER MODEL FOR FAULT RECOGNITION IN HIGH VOLTAGE TRANSFORMER **9**

Introduction – Hyperplanes – Linear SVM – Non-linear SVM: Gaussian, Sigmoidal and radial Basis Function – Multi-class SVM – Error-correcting output code – Fault recognition in HV transformer using SVM with balanced and imbalanced dataset.

CONSTRUCT A DEEP NEURAL NETWORK ALGORITHM FOR IMBALANCED DATASET FOR CLASSIFICATION OF FAULTS IN HIGH HIGH-VOLTAGE CABLE **9**

Conversion of imbalanced dataset into balanced dataset: Under sampling; oversampling; hybrid sampling – Importance of DNN in dataset conversion – Generative adversarial network – Conditional GAN – WGAN –Recognition of HV cable fault using DNN: ResNet 51; VGG 19 and its hyperparameters tuning.

APPLY OPTIMIZATION TECHNIQUES TO TUNE THE HYPERPARAMETERS IN DEEP NEURAL NETWORK **9**

CNN and its hyperparameters – Different training optimizers – Learning rate – Feature extraction – Feature fusion – Network fusion – Softmax –activation function – cross validation –Pattern recognition of fault in HV insulator using DNN with and without hyperparameter tuning using Bayesian optimization.

L: 45; TOTAL: 45 PERIODS

REFERNCES

1. M. Gopal, Applied Machine Learning, Second Edition, McGraw Hill Education (India) Private Limited, 2022.
2. Kuffel E., Zaengl W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsevier India Pvt. Ltd, 2008.
3. Dieter Kind and Hermann Karner, “High Voltage Insulation Technology”, (Translated from German by Narayana Rao Y., Friedr. Vieweg & Sohn, Braunschweig), 1985.
4. Stefano Zunino, Marino Sforna and Fabrizio Ferrari, “High Voltage Power Transformers: State of the art and technological innovations (Energy Engineering), Institution of Engineering and Technology, 2024.
5. Naidu M.S. and Kamaraju V., “High Voltage Engineering”, McGraw Hill, 6th Edition, 2020.
6. IEC – 60270, “HV Test technique – Partial Discharge Mechanism”, 3rd Edition, December 2000.

Estd : 1984

23HE11E **MACHINE LEARNING** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Explain the concepts of machine learning
CO2: Explore the supervised learning techniques
CO3: Summarize the unsupervised learning techniques
CO4: Recognize the feature and optimize the features
CO5: Build Deep Learning architecture models

INTRODUCTION 9

Machine Learning: History - Applications; Types of machine learning - Design of a learning system - Perspectives and issues in machine learning; Basic statistics: Variance and Covariance - Curse of dimensionality - Conditional Probability.

SUPERVISED LEARNING 9

Regression: Introduction - Linear Regression - Least Squares - Under fitting and Overfitting - Cross-Validation - Lasso Regression - Logistic Regression; Classification: Linear and Non-linear models - Support Vector Machines Multi class SVM - Kernel Methods; K-Nearest Neighbours.

UNSUPERVISED LEARNING 9

Unsupervised Models: Measuring dissimilarity – Spectral clustering –Hierarchical clustering – K-Means clustering – Fuzzy C Means Clustering – Dimensionality Reduction using Principal Component Analysis

ANALYTICAL AND FEATURE LEARNING 9

Analytical Learning: Discovering new features – Deductive Learning – Knowledge level learning – Feature Learning : Feature Selection – Greedy Selection Approaches – Feature Manipulation and Normalization – Dictionary Learning with Auto-encoders.

NEURAL NETWORK AND DEEP LEARNING ALGORITHM 9

Neural Networks: The Brain and the Neuron - Perceptron learning algorithm; Multi-Layer Perceptron: Back propagation algorithm - Error - Multi-layer perceptron in practice with Time Series Signal; Deep Learning: Introduction - Convolution Neural Networks –Training Optimizers; Role of Hyperparameters; Case Study: Image Classification.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Ethem Alpaydin, ``Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)'', Fourth Edition, MIT Press, 2020.
2. Stephen Marsland, ``Machine Learning - An Algorithmic Perspective'', Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2015
3. Kevin P. Murphy, —Machine Learning: A Probabilistic Perspective‖, MIT Press, 2012
4. Shai Shalev-Shwartz and Shai Ben-David, —Understanding Machine Learning: From Theory to Algorithms‖, Cambridge University Press, 2014
5. Christopher M. Bishop, —Pattern Recognition and Machine Learning‖, Springer, 2011.
6. https://www.coursera.org/learn/machine-learning
7. http://machinelearningmastery.com/best-machine-learning-resources-forgettingstarted/
8. https://www.udemy.com/machinelearning/

23HE12E **PULSE POWER ENGINEERING** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: identify the static and dynamic breakdown strength of dielectric materials
CO 2: evaluate the energy storage in Marx generators and pulse discharge capacitors
CO 3: distinguish the types and operation of various switches
CO 4: illustrate the pulse forming networks
CO 5: recognize the pulse transmission and transformation theory

BREAKDOWN STRENGTH OF DIELECTRIC MATERIALS **9**

Introduction – Gases-static breakdown – Pulsed breakdown – Spark formation – Liquids – Basic electrical process – Steamer breakdown – Practical considerations – Solids – General observation – Charge transport – Injection and Breakdown – Statistical Interpretation of breakdown Strength Measurements.

ENERGY STORAGE **9**

Pulse Discharge Capacitors – Marx Generators – Classical Marx generators – LC Marx Generator – Basic Pulsed – Power Energy Transfer Stage – Inductive energy storage – Power and voltage multiplication – Rotors and homo polar Generators.

SWITCHES **9**

Closing switches – Gas switches – Semi conductor closing switches – Magnetic switches – Summary –Opening switches – Fuses – Mechanical interrupters – Superconducting opening Switches – Plasma opening switches – Plasma flow switches – Semiconductor opening switches.

PULSE FORMING NETWORKS **9**

Transmission lines – Terminations and junctions – Transmission lines with losses – The finite transmission line as a circuit element – Production of pulses with lossless transmission lines – RLC networks – Circuit simulation with LEITER.

PULSE TRANSMISSION AND TRANSFORMATION **9**

Self magnetic insulation in vacuum lines – Vacuum break down in metallic surfaces – Qualitative description of self magnetic insulation – Quantitative description of self magnetic insulation – Pulse Transformers – High Voltage Power supplies – Capacitor-Charging Techniques – Cascade Circuits –Transformation Lines.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Hansjoachim Bluhm, “Pulsed Power Systems: Principles and Applications”, Springer; 2006.
2. Pai S.T., “Introduction to High Power Pulse Technology (Advanced Series in Electrical and Computer Engineering)”, Wspc Publisher, 1995.
3. Paul W. Smith, “Transient Electronics: Pulsed Circuit Technology”, Wspc, Wiley; First Edition, 2002.
4. Martin et al., J. C. Martin on Pulsed Power, Plenum Press, 1996.
5. G.A. Mesyats, Pulsed Power, Kluwer Academics/Plenum 2005.

23HE13E DESIGN OF SUBSTATION L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: explain the fundamental concepts of AIS, GIS and MTS substation
CO2: describe the equipment and layout of AIS, GIS and MTS substation
CO3: summarize the insulation coordination of AIS, GIS and MTS substation
CO4: analyze the grounding and shielding of substation
CO5:Interpret the basic tools required for Communication, substation integration and automation.

INTRODUCTION TO AIS, GIS AND MTS 9

Introduction – characteristics – comparison of Air Insulated Substation (AIS), Gas Insulated Substation (GIS), Mixed technology switchgear (MTS) substation– main features of substations, Environmental considerations, Planning and installation- GIB / GIL - budgeting-Financing - traditional and innovative substation design.

MAJOR EQUIPMENT AND LAYOUT OF AIS, GIS AND MTS 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 half scheme-ring bus.

INSULATION COORDINATION OF AIS, GIS AND MTS 9

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

GROUNDING AND SHIELDING 9

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

SUBSTATION INTEGRATION AND AUTOMATION 9

Interface between Automation and the Substation-State (Status) Monitoring-Control Functions-Communication Networks inside the Substation-Testing Automation-Substation Communications: Supervisory Control and Data Acquisition (SCADA): Functional Requirements- Communication Requirements-Relay Communication Requirements-Components of a SCADA System-Structure of a SCADA Communication Protocol: Past, Present, and Future.

L: 45; TOTAL: 45 PERIODS

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. Pritindra Chowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2008.
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

8. Hermann Koch , “Gas Insulated Substations”, Wiley-IEEE Press,2014
9. IEEE Std 80, IEEE Guide for Safety in AC Substation Grounding – 2013
10. IS Standard 3043 “CODE OF PRACTICE FOR EARTHING (First Revision)”; 1987.
11. Working Group JWG B3.35/CIRED, “Substation earthing system design optimisation through the application of quantified risk analysis” CIGRE 749, 2018.
12. CIGRE Green Book, “Substation”, Study Committee B3, PP 83 -155.
13. Working Group WG 23.03, “General guidelines for the design of outdoor AC substations. (2nd version)” CIGRE 161, 2000.

23HE14E FLEXIBLE AC TRANSMISSION SYSTEMS L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Explain the basic concepts of Power transmission networks and FACTS controllers (K2)
CO2: Apply and Analyze the Static Shunt Controllers and their applications in Power System (K3)
CO3: Apply and analyze the variable reactance model of Series Compensators and their Families (K3)
CO4: Explain the basic principle of operation of Unified Power Flow Controllers (K3)
CO5: Analyze the need of different FACTS controllers co-ordination and their Interaction (K3)

INTRODUCTION 9

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- Principles of operation - Steady state model and characteristics of a static voltage regulators and phase shifters - power circuit configurations

STATIC SHUNT COMPENSATORS 9

Configuration of Static Var Compensator- voltage regulation by SVC- Modeling of SVC for load flow analysis Design of SVC to regulate the mid-point voltage of SMIB system- Applications: Enhancement of transient stability- Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics Applications: Steady state power transfer– Enhancement of transient stability.

STATIC SERIES COMPENSATORS 9

Concepts of Controlled Series Compensation- Operation of TCSC, GCSC and TSSC - Analysis of TCSC Operation - Modeling of TCSC for load flow studies- Variable reactance model – Applications – Static Synchronous Series Compensator – Operation of SSSC and the control of power flow – Modeling of SSSC in load flow and transient stability studies – Applications: SSR Mitigation

UNIFIED POWER FLOW CONTROLLERS 9

Principle of operation of UPFC and Power flow control – Modes of operation- Applications modeling of UPFC for load flow studies and transient stability studies- Principle of operation of IPFC- Applications- Comparative Evaluation and Future direction of different types of FACTS controllers.

CO-ORDINATION OF FACTS CONTROLLERS **9**

Controller interactions – SVC - SVC interaction– SVC-TCSC interaction- TCSC-TCSC interaction- Coordination of multiple controllers using linear Control techniques and nonlinear Control techniques – Control coordination using genetic algorithms.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Mohan Mathur R. and Rajiv K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi.
3. Padiyar K.R.," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008.
4. John A.T., "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.

23HE15E **POWER QUALITY** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: describe the term and definition of power quality (K2)
CO 2: Analyze voltage sag problems and suggest preventive techniques (K3)
CO 3: Identify the harmonic sources and the effects of harmonic distortion (K2)
CO 4: explain the active compensation techniques used for power factor correction (K2)
CO 5: Explain the need for harmonic filtering and the harmonic filtering devices (K3)

POWER QUALITY – AN INTRODUCTION **9**

Overview of power quality phenomena -Basic terminologies –Power Quality Issues – Power acceptability curves- IEC and IEEE definitions-Causes for reduction in Power Quality – Power Quality Standards and Monitoring

VOLTAGE IMBALANCE & THEIR IMPACTS **9**

Voltage variations - Voltage sags and short interruptions – flicker-longer duration variations-sources – range and impact on sensitive circuits-standards – solutions and mitigations – equipment and techniques. Interruptions - Origin of Long & Short interruptions – influence on various equipments – monitoring & mitigation of interruptions.

SOURCES OF HARMONICS AND THEIR IMPACTS **9**

Important harmonic introducing devices – SMPS - Three Phase power converters - arcing devices saturable devices - harmonic distortion of fluorescent lamps - effect of power system harmonics on power system equipment and loads.

HARMONIC FILTERING **9**

Active Harmonic Filtering - Shunt Injection Filter for single phase , three-phase three-wire and three-phase four wire systems-d-q domain control of three phase shunt active filters - UPS - constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag swell and flicker problems.

COMPENSATORS-DISTRIBUTION SYSTEM **9**

Power factor improvement- Passive Compensation- Passive Filtering- Harmonic Resonance - Impedance Scan Analysis - Active Power Factor Corrected Single Phase Front End-Control Methods for Single Phase APFC -Three Phase APFC and Control Techniques - PFC Based on Bilateral Single Phase and Three Phase Converter static var compensators.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. G.T.Heydt, “Electric Power Quality”, Stars in Circle Publications, 1991
2. Math H. Bollen , “Understanding Power Quality Problems”, IEEE Press,1st Edition,2001
3. J. Arrillaga, “Power System Quality Assessment”, John Wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A.R.Wood, Power system Harmonic Analysis, Wiley, 1997
5. Wilson E Kazibwe, Musoke H Sendaula, “Electic Power quality control techniques”, Van Nostr and Rein hold, NewYork,1993
6. J. Schlabbach,D. Blume,T. Stephanblome , “Voltage quality in Electrical Power Systems”,IEE,2001.
7. Roger C.Dugan/ Mrak F. McGranaghan, Surya santoso & H.Wayne Beaty, “Electrical power systems quality”, Tata Mc Graw-Hill, 2010.
8. George J. Walkilesh, “Power Systems Harmonics”, Springer, 2007.

23HE16E **RESTRUCTURED POWER SYSTEMS** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: analyze the basic reasons and motivations for restructuring worldwide.
CO2: explain the roles and responsibilities of different entities in electricity Market
CO3: illustrate various methods of congestion management in deregulated power system
CO4: interpret analyze the ancillary services management
CO5: differentiate the framework of US and Indian power sectors

INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY **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.

POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT **9**

Role of the independent system operator- Operational planning activities of ISO: ISO in Pool markets - ISO in Bilateral markets - Operational planning activities of a GENCO: GENCOs in Pool and Bilateral markets - market participation issues, competitive bidding

TRANSMISSION CONGESTION MANAGEMENT **9**

Definition of Congestion - 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.

ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK **9**

Introduction of ancillary services –Types of Ancillary services –Classification of Ancillary services – Load generation balancing related services –Voltage control and reactive power support devices –Black start capability service –Market for ancillary service –Co-optimization of energy and reserve services -International comparison - Transmission pricing –Principles –Classification – Role in transmission pricing methods –Marginal transmission pricing paradigm –Composite pricing paradigm –Merits and demerits of different paradigm- loss allocation methods.

REFORMS INDIAN POWER SECTOR **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.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Mohammad Shahidehpour, Muwaffaq Alomoush, “Restructured electrical power systems: operation, trading and volatility” Marcel Dekker Pub., 2001.
2. Kankar Bhattacharya, Math H.J.Boolen, and JaapE. Daadler, "Operation of restructured power systems”, Kluwer Academic Pub., 2001.
3. Paranjothi, S.R., “Modern Power Systems: The Economics of Restructuring”, New Age International Publishers, First Edition: 2017.
4. Sally Hunt, "Making competition work in electricity”, John Willey and Sons Inc. 2002.
5. Steven Stoft," Power System Economics: Designing Markets for Electricity”, Wiley-IEEE Press, 2002.
6. A.Khaparde, A.R.Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/.

23HE17E POWER SYSTEM PLANNING AND RELIABILITY **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: analyze load forecasting & reliability
CO2: describe power system economics
CO3: Summarize the knowledge related to generation and transmission planning
CO4: Interpret the generation system reliability analysis
CO5: explain the transmission system reliability analysis

LOAD FORECASTING & RELIABILITY **9**

Classification and characteristics of loads - Approaches to load forecasting - Forecasting methodology- Energy forecasting - Basic Reliability Concepts: General reliability function, Markov Chains and processes and their applications, simple series and parallel system models - load forecasting uncertainty, Spinning Generating Capacity Reliability Evaluation: Spinning capacity evaluation.

POWER SYSTEM ECONOMICS **9**

Financial Planning, Techno – Economic Viability, Private Participation, Financial Analysis, Economic Analysis, Economic Characteristics – Generation Units, Transmission, Rural Electrification Investment, Total System Analysis, Credit - Risk Assessment, Optimum Investment, Tariffs.

GENERATION AND TRANSMISSION PLANNING **9**

Objectives of generation planning - Factors affecting Generation Planning - Sources of Generation- Transmission Planning Criteria, Right – of – Way, Network Studies, High – Voltage Transmission, Conductors, Sub – Stations, Power Grid, Reactive Power Planning, Energy Storage.

GENERATION SYSTEM RELIABILITY ANALYSIS **9**

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served, Determination of reliability of ISO and interconnected generation systems

TRANSMISSION SYSTEM RELIABILITY ANALYSIS **9**

Deterministic contingency analysis-Average interruption rate method -The frequency and duration method - Stormy and normal weather effects probabilistic load flow - Fuzzy load flow probabilistic transmission system reliability analysis - Determination of reliability indices like LOLP and expected value of demand not served.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. R.L. Sullivan, “Power System Planning”, Tata McGraw Hill Publishing Company Ltd, 2012.
2. X.Wang & J.R.McDonald, “Modern Power System Planning”, McGraw Hill Book Company, 1994.
3. Dr.K.Uma Rao, “Power system operation & control”, Wiley-India, First edition, 2013.
4. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press, 2009.
5. Cepin, Marko, “Assessment of Power System Reliability”, Springer, 2011.

23HE18E **SMART GRID** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: describe the basic concepts and design of smart grid
CO 2: explain the functionalities of smart grid technologies
CO 3: Illustrate the various distributed energy technologies
CO 4: apply the various protective and communication technologies in smart grid
CO 5: employ the high performance computing for smart grid applications

INTRODUCTION TO SMART GRID **9**

Basics of power systems-the definition of smart grid-need for smart grid-smart grid domain-enablers of smart grid- present development & International policies in Smart Grid regulatory challenges-smart-grid activities in India. Smart Grid Market Drivers- Functions of Smart Grid Components-Smart Grid Architecture

SMART GRID TECHNOLOGIES **9**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Distribution systems: DMS, Volt/VAR control, Fault Detection Isolation and service restoration, Outage management, High Efficiency Distribution Transformers, Phase Shifting Transformers

DISTRIBUTED ENERGY TECHNOLOGIES **9**

Distribution Generation Technologies Introduction to Distribution Energy Sources, Renewable Energy Technologies – Micro grids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

PROTECTIVE AND COMMUNICATION ELEMENTS IN SMART GRID **9**

Advanced metering Infrastructure (AMI) - AMI needs in the smart grid-Phasor Measurement Unit (PMU)-Intelligent Electronic Devices (IED) and their application for monitoring and protection-Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols.

DATA ANALYTICS IN SMART GRID **9**

Data Analytics: Benefits, tools, Challenges, need of artificial intelligence and machine learning for Smart grid applications, Introduction to cloud computing, edge computing, and security issues-introduction to Internet of things (IoT) - applications of IoT in Smart Grid.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase, CRC, 2018.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, John Wiley, 2012.
3. James Momoh ,Smart Grid Fundamentals of Design and Analysis, IEEE press 2012
4. S.Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 1st Edition, 2013.
5. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & sons Inc, 2012.
6. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
7. Vinod Chandra S. S “Artificial Intelligence and Machine Learning” PHI Learning in 2014.
8. Misra Sudip, ”Introduction to IoT” Cambridge University Press, 2014

Estd : 1984

23HE19E **CONTROL OF ELECTRIC DRIVES** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: acquire and apply knowledge of motor dynamics in electrical engineering
CO2: Formulate and design of converter and chopper fed DC drives and investigate the performance characteristics
CO3: Design the closed loop controller for DC drive and interpret the performance parameters.
CO4: explore the stator side control of Induction motor drives and analyze the characteristics of induction motor drive through VSI and CSI
CO5: investigate the rotor side control of induction motor drive and comprehend the impact of slip power control

ACQUIRE AND APPLY KNOWLEDGE OF MOTOR DYNAMICS IN ELECTRICAL ENGINEERING **9**

Review of DC motor types – Speed - Torque & Load – Torque Characteristics – Field and Armature Speed Control - Ward Leonard control – Motor dynamic equations, Requirements of drives characteristics – Stability of drives – Multi quadrant operation

FORMULATE AND DESIGN OF CONVERTER AND CHOPPER FED DC DRIVES AND INVESTIGATE THE PERFORMANCE CHARACTERISTICS 9

Phase Control – Analysis of separately excited and Series DC motor with Power Converters - steady state operation of a chopper fed drive – Performance parameters and Characteristics – Multi quadrant Control of Chopper fed DC drive – Regenerative braking

DESIGN THE CLOSED LOOP CONTROLLER FOR DC DRIVE AND INTERPRET THE PERFORMANCE PARAMETERS 9

Equivalent circuit - Transfer function of self, separately excited DC motors - Linear Transfer function model of power converters – P,PI & PID Controller : Transfer function for controller design, current controller specification and design, speed controller specification and design.

EXPLORE THE STATOR SIDE CONTROL OF INDUCTION MOTOR DRIVES AND ANALYZE THE CHARACTERISTICS OF INDUCTION MOTOR DRIVE THROUGH VSI AND CSI 9

Review of Induction motor speed – torque characteristics – Equivalent circuit – constant flux and flux weakening operation – Six step inverter - Closed loop variable frequency PWM inverter fed induction motor (IM) with braking- Variable frequency Current Source Inverter fed IM drives

INVESTIGATE THE ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVE AND COMPREHEND THE IMPACT OF SLIP POWER CONTROL 9

Review of Rotor Control - Static Scherbius drives – Static and modified Kramer drives – Sub-synchronous and super-synchronous speed operation of induction machines – Closed loop control of Slip ring Induction motor drive – Slip Power recovery scheme.

L: 45; TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc, 1989
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2015.
3. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education, 2015

REFERENCES:

1. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, 5th Edition, 2019.
2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw- Hill publishing company Ltd., New Delhi, 2018.
3. P.C Sen, “Thyristor DC Drives, John wiley and sons, New York, 1981.
4. W. Leonhard, “Control of Electrical Drives”, Narosa Publishing House, New Delhi, 6th Edition, 2019.

23HE20E	ADVANCE ELECTRIC DRIVES	L	T	P	E	C
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COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: illustrate the principles of vector control and direct torque control of induction motor

CO2: recognize various speed and flux estimation techniques for sensorless vector control of induction motor.

CO3: describe control strategies of synchronous motor.

CO4: outline control strategies of reluctance motor.

CO5: analyse the control techniques of Permanent Magnet Synchronous Motor (PMSM), Brushless DC Motor (BLDC).

ILLUSTRATE THE PRINCIPLES OF VECTOR CONTROL AND DIRECT TORQUE CONTROL OF INDUCTION MOTOR **L:9**

Principles of vector control, direct vector control, derivation of indirect vector control, implementation-block diagram, estimation of flux, flux weakening operation. DTC principle, operation and control and its comparison with vector control of IM.

RECOGNIZE VARIOUS SPEED AND FLUX ESTIMATION TECHNIQUES FOR SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR. **L:9**

Slip and speed estimation at low performance, rotor angle and flux linkage estimation at high performance, rotor speed estimation scheme, estimators using rotor slot harmonics, model reference adaptive systems, extended Kalman filter, injection of auxiliary signal on salient rotor.

DESCRIBE CONTROL STRATEGIES OF SYNCHRONOUS MOTOR. **L:9**

Synchronous motor and its characteristics- Control strategies-Constant torque angle control, power factor control, constant flux control, flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams. Sensorless control and flux observer

OUTLINE CONTROL STRATEGIES OF RELUCTANCE MOTOR. **L:9**

SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies, SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple Instantaneous Torque control -using current controllers-flux controllers.

ANALYSE THE CONTROL TECHNIQUES OF PERMANENT MAGNET SYNCHRONOUS MOTOR (PMSM), BRUSHLESS DC MOTOR (BLDC). **L:9**

Principle of operation and control of BLDC and PMSM Machine, Sensing and logic switching scheme, These motors as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor - current controlled Brushless dc motor Servo drive.

TEXT BOOKS:

1. R.Krishnan, “Electric Motor Drives “Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
2. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002
3. Peter Vas, “Sensorless Vector and Direct Torque control”, Oxford Science Publications, 1998.

REFERENCES:

1. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw- Hill publishing company Ltd., New Delhi, 2002.
2. W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992.
3. Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988
4. .Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition, 2009.
5. S. B. Dewan, Gordon R. Slemon and A. Straughen: Power Semiconductor Drives, John Wiley Pub.1996.
6. W. Shepherd, D. T. W. Liang and L.N. Hulley: Power Electronics and Motor Control, 2nd Edition, Cambridge Univ. Press, 1995.

L: 45; TOTAL: 45 PERIODS

23HE21E	EVOLUTIONARY COMPUTING	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO 1: explain the basic concepts of evolutionary computation.
CO 2: classify the various representations, selection and search operations
CO 3: discuss the basics of fitness evaluation and constraint handling mechanism.
CO 4: outline the concepts of hybrid systems.
CO 5: interpret the effect of parameter setting and applications.

EXPLAIN THE BASIC CONCEPTS OF EVOLUTIONARY COMPUTATION **L:9**

Introduction – Possible applications of evolutionary computations – History of evolutionary computation – Genetic algorithms – Evolution strategic – Evolutionary programming – Derivative methods – Stochastic processes – Modes of stochastic convergence – Schema processing – Transform methods – Fitness landscape – Probably Approximately Correct(PAC) learning analysis – Limitation of evolutionary computation methods – Local performance measures.

CLASSIFY THE VARIOUS REPRESENTATIONS, SELECTION AND SEARCH OPERATIONS **L:9**

Representation – Binary strings – Real-valued vectors – Permutations – Finite-state representation – Parse trees – Guidelines for a suitable encoding – Other representations Selection – Proportional selection and sampling algorithms – Tournament selection – Rank based selection – Boltz Mann selection – Other selection methods – Hybrids Generation gap methods – A comparison of selection mechanisms – Interactive evolution – Search Operators – Mutation – recombination – Other operators.

DISCUSS THE BASICS OF FITNESS EVALUATION AND CONSTRAINT HANDLING MECHANISM **L:9**

Fitness Evaluation – Encoding and decoding functions – Competitive fitness evaluation – Complexity based fitness evaluation – Multi objective optimization – Constraint handling techniques – Penalty functions – Decoders – Repair algorithms – Constraint

preserving operators – Other constraint handling methods – Constraint satisfaction problems – Population structures – Niching Methods – Specification methods – Island (migration) models.

OUTLINE THE CONCEPTS OF HYBRID SYSTEMS. **L:9**

Self-adaptation – Meta evolutionary approaches – Neural – Evolutionary systems – New areas for evolutionary computation research in evolutionary systems – Fuzzy-Evolutionary Systems – Combination with Other Optimization Methods – Combination with local search – Combination with dynamic programming – Simulated annealing and tabu search – Comparison with existing optimization.

INTERPRET THE EFFECT OF PARAMETER SETTING AND APPLICATIONS. **L:9**

Heuristics for Parameter setting Issues – Population size – Mutation parameters – Recombination parameters – Implementation of Evolutionary Algorithms – Efficient implementation of algorithms – Computation time of evolutionary operators – Applications – Classical optimization problems – Control Identification – Scheduling – Pattern recognition – Simulation models.

REFERENCES:

1. Thomas Back et al, “Handbook on evolutionary computation”, Institute of Physics, Publishing, 2000.
2. Xin Yao, “Evolutionary Computations: Theory and Applications”, World Scientific 39 Publishing, 1999.
3. Goldberg, “Genetic algorithm in search, optimization and machine learning”, Addison Wesley, 1998.
4. Davis, “Hand book on Genetic Algorithms”, NewYork, 1991.
5. Kenneth A De Jong, “Evolutionary Computation: A Unified Approach”, MIT Press, 2006.

L: 45; TOTAL: 45 PERIODS

23HE22E	OPTIMIZATION TECHNIQUES OF HIGH VOLTAGE ENGINEERING	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Analyze the metrics for assessing the supervised learning algorithm
CO2: perform optimization using linear and Non-linear programming
CO3: Determine the deep learning model for pattern recognition applications
CO4: Determine the status of the high-voltage insulator and Bushing
CO5: Develop and optimize CNN architecture for condition monitoring of high voltage transformer

ANALYZE THE METRICS FOR ASSESSING THE SUPERVISED LEARNING ALGORITHM **L:9**

Toward Intelligent machines – Data representation – Domain knowledge for productive use of machine learning – Forms of Learning – Bias and Variance – Occam’s Razor Principal and overfitting avoidance – Ensemble Learning – Estimating Generalization errors – Metrics for assessing regression and classification accuracy.

PERFORM OPTIMIZATION USING LINEAR AND NON-LINEAR PROGRAMMING **L:9**

Linear programming, Simplex algorithm – Duality – Revised simplex algorithm – Sensitivity analysis. Nonlinear programming: Unconstrained optimization – Gradient-based methods – Newton's method – Quasi-Newton's method – Constrained optimization – Penalty function methods - Unconstrained Geometric Programming-Constrained Geometric Programming

DETERMINE THE DEEP LEARNING MODEL FOR PATTERN RECOGNITION APPLICATIONS **L:9**

Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning– Matrix convolution – Convolution Layer – Pooling Layer – Fully connected Layer – Training optimizers – ADAM, NAG, ADADELTA, NADAM, SGDM, RMSPROP – Activation function – Different deep learning architecture - LSTM.

DETERMINE THE STATUS OF THE HIGH-VOLTAGE INSULATOR AND BUSHING **L:9**

Insulator crack identification using different training optimizers – Bushing fault recognition using different CNN architecture – Hydrophobicity class determination using LSTM architecture.

DEVELOP AND OPTIMIZE CNN ARCHITECTURE FOR CONDITION MONITORING OF HIGH VOLTAGE TRANSFORMER **L:9**

Types of fault in transformer – dissolved gas analyzer – DUVAL triangle approach – CNN based fault detection with learning rate – different CNN architecture

REFERENCES:

1. S.S.Rao, "Optimization theory and Applications", New Age International, 1984.
2. Kalyanmoy Deb, "Optimization for Engineering Design", PHI, 2012.
3. S.D.Sharma, "Operations Research – Theory and Applications", Macmillan Publications, 2009.
4. H.A.Taha , "Operation Research", TMH, 1982.
5. R.LRardin, "Optimization in operations research", Pearson New International, 2014.
6. Belagundu&Chandraputla, "Optimization Concepts and Applications in Engineering", Pearson Asia, 2011.
7. M.C.Joshi, K.M.Moudgalya, "Optimization Techniques theory and practice", Narosa Publications, 2004.

L: 45; TOTAL: 45 PERIODS

23HE23E **ENERGY MANAGEMENT** **L T P E C**

3 0 0 0 3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Apply the energy management skills and strategies in the energy management system
CO2: Execute economic aspects in energy management
CO3: Investigation of cogeneration in industry and waste heat recovery techniques and devices
CO4: Design suitable energy monitoring system to analyze and optimize the energy consumption in an organization
CO5: Analyze the basics of advanced energy management with application on different sectors

APPLY THE ENERGY MANAGEMENT SKILLS AND STRATEGIES IN THE ENERGY MANAGEMENT SYSTEM **L : 9**

Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.

EXECUTE ECONOMIC ASPECTS IN ENERGY MANAGEMENT **L : 9**

Fundamental of Energy conservation, Energy Management and Audit, Basics of Energy Demand and Supply, Principles of Economic analysis in the Energy Management and Audit programme, Supply side and demand side energy management, Boilers and Firing System, Steam, Condensation Systems.

INVESTIGATION OF COGENERATION IN INDUSTRY AND WASTE HEAT RECOVERY TECHNIQUES AND DEVICES **L : 9**

Energy Conservation and Management in power plant, Energy conservation in Buildings, Heating, Ventilation and Air Conditioning System, Degree day in energy use monitoring, Energy Conservation Opportunities, in chemical industries, Waste heat recovery, Co-generation, Energy Conservation in Agricultural Sector, Energy conservation in illumination engineering, Combustion stoichiometry, air-fuel ratio, optimum loading in boilers.

DESIGN SUITABLE ENERGY MONITORING SYSTEM TO ANALYZE AND OPTIMIZE THE ENERGYCONSUMPTION IN AN ORGANIZATION **L : 9**

First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses, Improvements. Energy Balance sheet and Management Information System (MIS) Energy Modeling and Optimization.

ANALYZE THE BASICS OF ADVANCED ENERGY MANAGEMENT WITH APPLICATION ON DIFFERENT SECTORS **L : 9**

Details of Energy management programme in industrial sector, Domestic sector, Agricultural and Transport sectors. Analysis of energy utilization in boiler and firing system. Evaluation of heat loss and heat gain in buildings systems, thermal design building systems, evaluation of window and glazing, solar simulation of building systems, Methods of improving thermal equality. Methods of improving thermal equality. Estimation on energy saving at the industrial houses, Energy budget. Estimation of energy loss in Electrical utilities. Electrical load management

L: 45; TOTAL: 45 PERIODS

REFERENCES:

1. General Aspects of Energy management and Energy audit, Second Edition, Bureau of Energy Efficiency, Ministry of Power, India, 2005
2. Energy Efficiency in Electrical Utilities, Second Edition 2005, Bureau of Energy Efficiency, Ministry of Power, India.
3. Energy management handbook, John Wiley and Sons Wayne C. Turner, 2006
4. D. Yogi Goswami, Frank Kreith, “Energy Management and Conservation Handbook”, CRC Press, 2008
5. Marguerite A.H Ruffner, Yacov Y. Haimes, “Energy Auditing and Conservation: Methods, Measurements, Management, and Case Studies”, Taylor and Francis, 1980.

23HE24E	NANO DIELECTRICS	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO 1: comprehend the nano material structure
CO 2: summarize the characteristics of nano materials.
CO 3: recall the methods of synthesization and characterization.
CO 4: describe the processing methods of nano composite and applications.
CO 5: design and fabricate the electrical insulations with nano dielectric materials.

COMPREHEND THE NANO MATERIAL STRUCTURE **L: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.

SUMMARIZE THE CHARACTERISTICS OF NANO MATERIALS. **L:9**

Nano composites and Properties- Metal-Metal nano composites, Polymer-Metal nano composites, Ceramic nano composites: Dielectric and CMR based nano composites. 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.

RECALL THE METHODS OF SYNTHESIZATION AND CHARACTERIZATION **L:9**

Synthesis of Nanomaterials by Physical Methods -Inert gas condensation, Arc discharge, Ball Milling, Molecular beam epitaxial-Chemical vapor 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, Thermo gravimetric Analysis, Differential Scanning Calorimetry.

DESCRIBE THE PROCESSING METHODS OF NANO COMPOSITE AND APPLICATIONS. **L:9**

Direct Mixing, Solution Mixing, Preparation and characterization of inorganic nanofillers properties, synthesis, characterization and applications of SiO2, TiO2, ZrO2, Al2O3 and CNT composite - Applications of nano filled materials for outdoor and indoor equipments.

DESIGN AND FABRICATE THE ELECTRICAL INSULATIONS WITH NANO DIELECTRIC MATERIALS. **L:9**

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

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 Kanello Poulos. 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.

L: 45; TOTAL: 45 PERIODS

23HE25E	OPTIMAL CONTROL AND FILTERING	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO 1: Explain the classification of optimal control problem.
CO 2: Solve the optimal control problems.
CO 3: Explain the numerical techniques for optimal control.
CO 4: Analyze the principles of filtering and estimation
CO 5: Analyze the kalman filter properties.

EXPLAIN THE CLASSIFICATION OF OPTIMAL CONTROL PROBLEM. **L:9**

Statement of optimal control problem – Problem formulation and forms of optimal Control – election of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

SOLVE THE OPTIMAL CONTROL PROBLEMS. **L:9**

Linear optimal regulator problem – Matrix Riccatti equation and solution method – Choice of weighting matrices – Steady state properties of optimal regulator – Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

EXPLAIN THE NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL. **L:9**

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods.

ANALYZE THE PRINCIPLES OF FILTERING AND ESTIMATION **L:9**

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

ANALYZE THE KALMAN FILTER PROPERTIES. **L:9**

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise

ratio improvement – Extended Kalman filter.

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.

L: 45; TOTAL: 45 PERIODS

23HE26E	DIGITAL CONTROL SYSTEM	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO 1: Estimate discrete time models, which approximate continuous time dynamics.
CO 2: Design a compensator for digital control system to achieve desired specification.
CO 3: Design digital compensators and analyze system stability using Z-plane methods
CO4: Analyze the state variable concepts in digital control system
CO5: Design and implement state-based control systems

ESTIMATE DISCRETE TIME MODELS, WHICH APPROXIMATE CONTINUOUS TIME DYNAMICS. **L:9**

Advantage of Digital Control – Principles of Signal Conversion – Basic Discrete Time Signal – Time Domain Models for Discrete Time Systems – Review of Z Transforms – Transfer Function Models –Sample and Hold System – Sampled Spectra and Aliasing – Reconstruction of Analog Signals – Selection of Sampling Rate –Principles of Discretization

DESIGN A COMPENSATOR FOR DIGITAL CONTROL SYSTEM TO ACHIEVE DESIRED SPECIFICATION **L:9**

Basic Digital Control Scheme – Z Domain Description of Sampled Continuous Time Plants – Z Domain Description of Systems with Dead Time – Implementation of Digital Controller – Digital PID controller – Digital Temperature Control System – Digital Position Control System – Stepping Motors and their Control

DESIGN DIGITAL COMPENSATORS AND ANALYZE SYSTEM STABILITY USING Z-PLANE METHODS **L:9**

Introduction - Z Plane Specifications of Control System Design – Digital Compensator Design Using Frequency Response Plots – Digital Compensator Design Using Root Locus Plots – Z Plane Synthesis – Stability on the Z Plane and Jury Stability Criterion

ANALYZE THE STATE VARIABLE CONCEPTS IN DIGITAL CONTROL SYSTEM **L:9**

State Descriptions of Digital Processors – State Description of Sampled Continuous Time Plants - State Description of System with Dead Time – Solution of State Difference Equations – Controllability and Observability.

DESIGN AND IMPLEMENT STATE-BASED CONTROL SYSTEMS **L:9**

State Regulator Design –State Observers – Separation Principle – State feedback with Integral control – Dead beat control by state feedback and dead beat observers - Pole Placement Design by State Feedback (Single Input) –Pole Placement Design by Output Feedback (Single Input)

REFERENCES

1. M.Gopal "Digital Control and State Variable Methods", 4th Edition, Tata Mc-Graw Hill, 2012.
2. Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004. 2. G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.

L: 45; TOTAL: 45 PERIODS

23HE27E	ROBOTICS AND INDUSTRIAL AUTOMATION	L	T	P	E	C
		3	0	0	0	3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO 1: Explain the individual components of Robotics.
CO 2: Summarize the kinematics transformation techniques used in Robotics.
CO 3: Explain about Jacobian matrix used for robotic differential motion and velocities
CO 4: Describe the role of image processing and vision system for an automation of robot.
CO5: Perform image analysis and object recognition to identify and classify objects

.

EXPLAIN THE INDIVIDUAL COMPONENTS OF ROBOTICS. **L:9**

Definition-Classification-History- Robots components - Degrees of freedom - Robot joints coordinates - Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors proximity and range sensors- social issues.

SUMMARIZE THE KINEMATICS TRANSFORMATION TECHNIQUES USED IN ROBOTICS. **L:9**

Mechanism-matrix representation - homogenous transformation - DH representation – Inverse kinematics-solution and programming-degeneracy and dexterity

EXPLAIN ABOUT JACOBIAN MATRIX USED FOR ROBOTIC DIFFERENTIAL MOTION AND VELOCITIES **L:9**

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian-Design - Lagrangian mechanics-dynamic equations-static force analysis.

DESCRIBE THE ROLE OF IMAGE PROCESSING AND VISION SYSTEM FOR AN AUTOMATION OF ROBOT. **L:9**

Sensor characteristics - Hydraulic, Pneumatic and Electric actuators-trajectory planning decentralised PID control- non-linear decoupling control.

PERFORM IMAGE ANALYSIS AND OBJECT RECOGNITION TO IDENTIFY AND CLASSIFY OBJECTS **L:9**

Two and three dimensional images-spatial and frequency domain representation-noise and edges - convolution masks - Processing techniques – thersholding - noise reductionedge detection -segmentation - Image analysis and object recognition.

REFERENCES

1. Saeed B. Niku, “Introduction to Robotics”, 2nd Edition, Pearson Education, 2010.
2. Fu, Gonzalez and Lee McGrahill, “Robotics”, International TATA McGraw Hill, 2008.
3. R.D. Klafter, TA Chmielewski and Michael Negin, “Robotic Engineering, An Integrated Approach”, Prentice Hall of India, 2003.

L: 45; TOTAL: 45 PERIODS

23HE28E **SPECTROSCOPIC METHODS** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: identify the various functional groups using vibration spectroscopy method
CO2: interpret the structure of molecules using UV-Visible Spectroscopy
CO3: predict the splitting pattern and interpretation of NMR spectra
CO4: identify the structure of molecules using mass spectrometry
CO5: interpret ESR spectra to identify the geometry of the molecules

CO1: identify the various functional groups using vibration spectroscopy method **9**

Infrared Spectroscopy: Absorption of IR radiation and molecular vibrations – Spectral feature of major functional groups and interpretation of molecules – Distinction between intermolecular and intra-molecular hydrogen bonding. Characteristics & IR absorption frequencies of simple molecules (water, phosphate, nitrate, acetate, sulphate and perchlorate) – Applications of IR spectroscopy

CO2: interpret the structure of molecules using UV-Visible Spectroscopy **9**

Ultraviolet Spectroscopy: Electronic energy levels – Types of electronic excitations in UV-Vis spectroscopy – Change in position and intensity of absorption – Spectra of simple organic compounds. Charge transfer spectra for complexes - Colour of transition metal ions and their complexes - Factors affecting the position of UV bands - Applications of UV-Visible spectroscopy.

CO3: predict the splitting pattern and interpretation of NMR spectra **9**

Nuclear Magnetic Resonance Spectroscopy: Principles of ^{1}H, ^{13}C NMR – Shielding mechanism – Chemical shift – Spin-spin coupling – Coupling constants – Splitting of signals – Applications of NMR

CO4: identify the structure of molecules using mass spectrometry **9**

Mass Spectrometry: Principle – Molecular peak, base peak, isotopic peak, metastable peak and their uses. Mass spectrum of organic compounds: Identification of acids, esters, alcohols, aldehydes and aromatic hydrocarbons.

CO5: interpret ESR spectra to identify the geometry of the molecules **9**

Spin-spin relaxation – Hyperfine splitting – Zeeman splitting – *g*-values – Factors affecting *g*-value – Determination of *g*-value – Zero field splitting – Applications of ESR spectroscopy.

L: 45; TOTAL: 45 PERIODS

TEXT BOOKS:

1. W. Kemp, Organic spectroscopy, 5th Edition., Bloomsbury Publishing India Pvt. Ltd, New Delhi, 2017
2. Francis X. Webster, David J. Kiemle, Robert M. Silverstein, David L. Bryce, Spectrometric Identification of Organic Compounds, 8th Edition, Wiley India Pvt. Ltd., Noida, 2014.
3. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan, Introduction to Spectroscopy, 5th Edition, Engage Learning India Private Limited, Noida, 2014.
4. DH Williams & I Flemming, Spectroscopic methods in Organic Chemistry, Springer, 2019.
5. P S Kalsi, Spectroscopy of Organic Compounds, New Age International publishers, New Delhi, 2007.
6. Jag Mohan, Organic Spectroscopy: Principles and Applications, CRC Press, 2004.

REFERENCES:

1. T.Tripathi Introduction to Spectroscopic Methods, 1st Edition, Astral International Pvt. Ltd., 2023.
2. J.D. Lee, Concise Inorganic Chemistry, 5th Edition, Wiley India Pvt. Ltd. Noida, 2023.
3. S.Bienz, L. Bigler, T. Fox, H.Meier, Spectroscopic Methods in Organic Chemistry, 3rd Edition, Auflage, 2021.

23HE29E **ANALYTICAL METHODS** **L T P E C**
3 0 0 0 3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: estimate the compounds by wet chemical methods
CO2: isolate the natural and synthetic compounds using chromatographic methods
CO3: familiar with working principles of various electro analytical instrumentation for qualitative and quantitative analysis
CO4: evaluate the kinetic properties of the compounds under the influence of temperature
CO5: acquire knowledge on radiochemical studies

CO1: estimate the compounds by wet chemical methods **9**

Wet chemical methods: Principle of volumetric analysis - neutralization - complexometric titrations - precipitation titrations – redox titrations – gravimetric analysis.

CO2: isolate the natural and synthetic compounds using chromatographic methods **9**

Chromatographic Methods: Principle – classification and applications of chromatographic techniques – paper chromatography – thin-layer chromatography – HPTLC – column chromatography – GC- MS and LC - MS.

CO3: familiar with working principles of various electro analytical instrumentation for qualitative and quantitative analysis 9

Electro analytical techniques: Principle and applications - conductometry– potentiometry (pH metric and ion selective electrodes) - cyclic voltammetry - amperometric titrations and electrogravimetry.

CO4: evaluate the kinetic properties of the compounds under the influence of temperature 9

Thermal methods: Principle, instrumentation and applications of thermogravimetry (TGA) – differential thermal analysis (DTA) – differential scanning calorimetry (DSC).

CO5: acquire knowledge on radiochemical studies 9

Principle – special precautions for radiochemical studies – equipment for measuring radio activity – scintillation counter, gamma Counter. Neutron activation analysis and PET (Positron Emission Tomography) - G M Counter – determination of characteristics of GM counter – determination of the absorption curve for ^{234}Th – ^{234}Pa sample.

L: 45; TOTAL: 45 PERIODS

TEXT BOOKS:

1. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical chemistry, engage Learning India Private Limited, Noida, 2021.
2. F.W. Finfield & D. Kealey, Principles and practice of Analytical chemistry, 5th Edition, Blackwell Science, United Kingdom, 2000.
3. Gary D.Christian, Analytical Chemistry, 6th Edition, John Wiley and sons Inc., New York, 1994.
4. Willard, Merit, Dean, Instrumental Methods of Analysis, 6th Edition, CBS Publishers and Distributors, New Delhi, 1986.
5. CJ Jeffery, J Bassett et al, Vogel's Textbook of Quantitative analysis, 5th Edition, Longmann ELBS Publications, Pearson India Education Services Pvt. Ltd., Noida, 2000.

REFERENCES:

1. R.Gopalan and K.S.Viswanathan, Analytical Methods: Interpretation, Identification, Quantification, Universities Press Private Limited, Chennai, 2018.
2. R.M. Verma Analytical Chemistry: Theory and Practice, 3rd Edition, CBS Publishers, New Delhi, 2020.
3. D.A. Skoog and D.M. West, Fundamental of Analytical Chemistry, Holt Rinehart and Winston Publications, 4th Edition, Newyork, USA, 1982.
4. H. Kaur, Instrumental Methods of Chemical analysis, Pragati Publication private limited, Surat, 2006.
5. B.K. Sharma, Instrumental Methods of Chemical Analysis, Goel Publications,15thEdition, Bareilly,1996

23HE30E ELECTROCHEMICAL STORAGE AND CONVERSION L T P E C
3 0 0 0 3

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: apply the concept of the thermodynamics, kinetics and mass transport to electrochemical devices.
CO2: measure the potential of electrochemical cell using various electro analytical methods
CO3: identify the suitable battery materials for improving the performance of the lithium battery
CO4: explain the working principle of super capacitors
CO5: identify the suitable methods for large scale production and storage of hydrogen gas

CO1: apply the concept of the thermodynamics, kinetics and mass transport to electrochemical devices **9**

Basic concepts of electrochemistry - thermodynamic in electrochemical cell: effect of temperature on Gibbs energy and entropy. Nernst equation-kinetics of electrochemical cell: electrode reactions – rate equations – current-voltage behaviour for electrochemical events. Mass transport concept: diffusion – migration – convection developed for charged and uncharged species in electrochemical systems. Charge transfer reactions in rechargeable batteries.

CO2: measure the potential of electrochemical cell using various electro analytical methods **9**

Primary cells – types – magnesium and aluminium based cells – magnesium reserve batteries. Secondary cells: classification based on electrolyte type - temperature of operation on the basis of electrodes - chemistry of the main secondary batteries. Batteries for electric vehicles – present status. Electrode potential: half cell, full cell, redox couple. Potential measurement: cyclic voltammetry– square wave voltammetry – linear sweep voltammetry – amperometric analyses – impedance measurement and analyses – charge-discharge analysis.

CO3: identify the suitable battery materials for improving the performance of the lithium battery **9**

Lithium batteries: Battery materials - positive and negative electrodes – electrolytes - current collector - conductive agents - separators and other accessories. Operational mechanisms of lithium batteries. Fabrications: coin, cylindrical, pouch and prismatic cells. Performance evaluation: safety issues - battery management systems – recycling.

CO4: explain the working principle of super capacitors **9**

Super capacitors: classification: EDLC and pseudocapcitor - asymmteric super capacitor and BATCAP. Components of a super capacitor: electrode material - electrolytes - separators. Operational mechanisms. Fabrication methods: Chemical vapour deposition (CVD), dip-coating, electrochemical deposition, 3D printing and spray coating.

CO5: identify the suitable methods for large scale production and storage of hydgrogen gas **9**

Sources of hydrogen, fuel cell – principle– construction and applications – production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods – storage of hydrogen metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

L: 45; TOTAL: 45 PERIODS

TEXT BOOKS:

1. C. A. Vincent, Modern Batteries, Edward Arnold, London, 1984.
2. R.Narayanan and B. Viswanathan, Chemical and Electrochemical energy systems, Universities Press Ltd., Hyderabad, India. 1998.
3. S.J.Apple by and F. K. Foulkes, Fuel cell Hand Book, Von Nostrand Reinhold, New York, 1989.
4. D.Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, New York 1983.

REFERENCES:

1. Y. Wu, R. Holze, Electrochemical Energy Conversion and Storage, 1st Edition, VCH-Wiley, Weinheim, New Delhi, 2022.

2. A. K. Samantara, S. Ratha, Electrochemical Energy Conversion and Storage Systems for Future Sustainability: Technological Advancements, 1st Edition, Apple Academic Press, USA, 2022.

23HE31E HIGH VOLTAGE PROTECTION AND SWITCHGEAR L T P E C
3 0 2 0 4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: analyze the characteristics of different types of electromagnetic, statics and numerical relays.

CO2: realize different microprocessor based numerical relays and protection schemes.

CO3: design and work with the concepts of digital and numerical relaying of various power apparatus

CO4: explore the relay coordination for the transmission line protection schemes

CO5: Analyze the arc quenching mechanisms used in air, oil and vacuum circuit breakers and apply technology to protect power system components.

Practical Component

CO6: Illustrate the power system issues under normal and abnormal conditions using ETAP and SCADA software

CO7: illustrate the operating characteristics of different types basic numerical relays

CO8: apply different digital protection schemes for motors and transformers

CO9: evaluate the different protection schemes of transmission line.

CO1: analyze the characteristics of different types of electromagnetic, statics and numerical relays: 9

Overview of protection systems and relaying, Comparison of Static Relays and electromechanical relays, Mathematical theory of relay, concept of digital simulation of relaying signals, Introduction to IEC protocols, Current and Voltage Transducers, Block diagram of numerical relay - Sampling theorem - Correlation with a reference wave - Least Error Squared (LES) technique - Digital filtering and numerical over- Current protection, Switched distance relay, Poly-phase relay, Frequency relay.

CO6: Illustrate the power system issues under normal and abnormal conditions using ETAP and SCADA software: 8

1. Relay coordination studies using ETAP software
2. GUI development for any one application using SCADA software
3. Simulation of various power system faults using SCADA software

CO2: realize different microprocessor based numerical relays and protection schemes: 9

Numerical Relay, Data Acquisition System, Numerical Relaying Algorithms, Removal of DC offset, Numerical overcurrent, Distance and Differential Protection, Realization of Microprocessor based Overcurrent, Directional, Impedance, Reactance, MHO and Quadrilateral Relays, Applications of Digital protection schemes for transmission lines, transformers and Generators, ANN based Numerical Protection. Standards in Protection: IEEE/IEC Protection Protocols.

CO7: illustrate the operating characteristics of different types basic numerical relays: 8

1. Characteristics of IDMT type Induction over current relay
2. Characteristics of digital over current relay
3. Testing on (i) Under Voltage Relay and (ii) Earth Fault Relay

CO3: design and work with the concepts of digital and numerical relaying of various power apparatus: 9

Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator, faults in a transformer, schemes used for transformer protection, digital protection of transformer

CO8: apply different digital protection schemes for motors and transformers 8

1. Differential protection of transformer
2. Motor protection using numerical relay

CO4: explore the relay coordination for the transmission line protection schemes: 9

Protection criteria for distribution system, Feeder Protection, Auto-reclosers and Sectionalizers, Coordination of overcurrent, distance and directional relay, Distance protection scheme, Wire Pilot protection schemes, Carrier current Protection schemes, Integrated substation protection and control.

CO9: evaluate the different protection schemes of transmission line. 6

1. Protection of Transmission line using Impedance relay

CO5: Analyze the arc quenching mechanisms used in air, oil and vacuum circuit breakers and apply technology to protect power system components: 9

Elementary principles of arc interruption, Recovery, Restriking Voltage and Recovery voltages.- Restriking Phenomenon, Average and Maximum RRRV - Current Chopping and Resistance Switching - CB ratings and Specifications, Types, Minimum Oil Circuit breakers, Air Blast Circuit Breakers, Vacuum, and SF6 circuit breakers.

L: 45; P: 30; TOTAL: 75 PERIODS

TEXT BOOKS:

1. L. P. Singh, “Digital Protection”, New Age International (P) Limited Publishers, New Delhi, 2nd Edition, 1997.
2. Transmission Network Protection- Paithankar Y. G. (Marcel & Dekker, New York)
3. Fundamentals of Power System Protection- Paithankar Y. G. & Bhide, Prentice Hall India Learning Private Limited, 2nd Edition, 2010.
4. J.C. Das , “Power System Protective Relaying (Power Systems Handbook)”, CRC Press, 1st Edition, 2017.

REFERENCES:

1. Johns, A.T. and Salman, S.K., Digital Protection for Power Systems, IEE Power Series (1995).
2. Rao, T.S.M., Power System Protection: Static Relays, TMH Publishing Company (2008).
3. B. Ram and D. N. Vishwakarma, Power System Protection and Switchgear, Tata McGraw Hill Education Pvt. Ltd. (2011).
4. Wu, Q.H., Lu, Z., Ji, T.Y., Protective Relaying for Power Systems using Mathematical Morphology, Springer (2009).
5. Digital Relay / Numerical relays – T.S.M. Rao, Tata Mc Graw Hill, New Delhi
6. NPTEL course on power system protection by S. A. Soman.

23HE32E SOFT COMPUTING TECHNIQUES L T P E C
3 0 2 0 4

COURSE OUTCOMES

Upon completion of this course, the students will be able to

Theory Component

CO 1: narrate the main components of soft computing
CO 2: explain ANN learning principles and the factors that affects ANN Performance
CO 3: brief the fuzzy rule based systems
CO 4: describe the basic concepts of genetic algorithms
CO 5: apply GN, FLC and GA to various electrical applications

Practical Component

CO6: perform various logic functions using McCulloch-Pitts neural net
CO7: implement various ANN structures to test the input patterns
CO8: develop programs using fuzzy inference system to control electrical drives
CO9: employ the GA various power system optimization and control problems
CO10: Deploy the soft computing techniques in electrical applications

CO1: narrate the main components of soft computing 9

Introduction to Soft computing – Importance – Main Components – Fuzzy logic – Artificial Neural Network – Introduction to evolutionary algorithms – Hybrid intelligent systems – Knowledge representation – Expert systems.

CO6: perform various logic functions using McCulloch-Pitts neural net 6

1. Write a program to perform AND, NOT, XOR functions using McCulloch-Pitts neural net
2. Write a program to solve the linearly separable problem using perceptron model

CO 2: explain ANN learning principles and the factors that affects ANN Performance 9

Introduction – model of ANN – architectures – learning methods – taxonomy of NN systems – Single-layer NN systems – back-propagation learning - properties of neural network – limitations – development of generalized neuron model – EX-OR problem testing – network complexity – problem complexity – learning complexity

CO7: implement various ANN structures to test the input patterns 6

1. Write a program to implement Adaline with Bipolar Inputs and Outputs
2. Write a program to implement Back Propagation Network for a Given Input Pattern
3. Write a program to controlling linear and nonlinear dynamic systems using neural network

CO 3: brief the fuzzy rule based systems 9

Introduction, Fuzzy set: Membership functions – Operations – Properties - Fuzzy relations - Fuzzy systems – fuzzy logic – fuzzification – fuzzy inference – fuzzy rule based systems – defuzzification.

CO8: develop programs using fuzzy inference system to control electrical drives 2

1. Write a program to plot various membership functions and to use fuzzy toolbox to model tips value that is given after a dinner based on quality (not good, satisfying, good and delightful) and service (poor, average or good) and the tip value ranges from Rs. 10 to 100

CO 4: describe the basic concepts of genetic algorithms 9

Introduction – History of genetics – Genetic algorithm: selection, crossover, mutation, survival of fittest, population size, evaluation of fitness function – effect of crossover probability on GA performance - effect of mutation probability on GA performance – main components of GA – Variants.

CO9: employ the GA various power system optimization and control problems 2

1. Write a program for the system identification problem i.e structural identification of the equation and the estimation of the model's parameters using genetic algorithm

CO 5: apply GN, FLC and GA to various electrical applications 9

Applications of GN model in electrical load forecasting problem – Applications of fuzzy rule based system in adaptive control – PID control and power system stabilizer – Simple GA (SGA) – Improved GA (IGA) – application of IGA in electrical load forecasting problem – Hybrid systems – integration of neural networks, fuzzy and GA.

CO10: apply the soft computing techniques in electrical applications 14

1. Develop a program for Short term load forecasting using neural network
2. Develop a program to control the electric motor drive using fuzzy inference system (FIS)
3. Implement the Economic load dispatch problem using GA
4. Applying the GA for tuning and control the PID controller
5. Develop a program integrating GA and FLC for load frequency control of two area power system network.

L: 45; P: 30; TOTAL: 75 PERIODS

REFERENCES:

1. Devendra K.Chaturvedi Soft Computing Techniques and its Applications in Electrical Engineering, Studies in Computational Intelligence, Volume 103, © 2008 Springer-Verlag Berlin Heidelberg
http://ndl.ethernet.edu.et/bitstream/123456789/33188/1/328.Devendra%20K.%20Chaturvedi.pdf
2. Jacek M Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
3. Zimmerman H.J., "Fuzzy set theory-and its Applications", Kluwer Academic Publishers, 1994.
4. Kosko.B, "Neural Networks and Fuzzy Systems", Prentice-Hall of India Pvt Ltd., 1994.
5. Klir G.J. and Folger T.A., "Fuzzy sets, Uncertainty and Information", Prentice-Hall of India Pvt.Ltd., 1993.
6. Driankov and Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers, 2001.

23HE33E POWER ELECTRONICS IN POWER SYSTEMS L T P E C
3 0 2 0 4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1: Select the appropriate compensating technique and controller based on the needs of inter connected power transmission systems. (CDL1)
CO2: Demonstrate the knowledge of shunt compensators for the end of line voltage support and transient stability problems (CDL1)
CO3: Analyze the operation and control of various Static Series Compensators (CDL1)
CO4: Demonstrate the function of Unified Power Flow Controllers: (CDL1)
CO5: Identify the power quality problems and demonstrate the knowledge of various types of filters and UPQC (CDL1)

Practical Component

CO6: evaluate the functions of various power electronic FACTS controllers.

CO7: assess the issues of damping to power system oscillations, real and reactive power control capability in power system

CO8: Interpret the design and working and of Power system Stabilizer.

CO9: analyse the operational aspects and their effectiveness in transient stability enhancement

CO10: learn the integration in power flow analysis and their effectiveness in distribution system for harmonic mitigation

CO1: Select the appropriate compensating technique and controller based on the needs of inter connected power transmission systems: 9

Reactive Power Flow Control in Power Systems: Control of dynamic power unbalances in Power System, Power flow control, Constraints of maximum transmission line loading, Benefits of FACTS Transmission line compensation, Uncompensated line, Shunt compensation, Series compensation, Phase angle control, Reactive power compensation, Shunt and Series compensation principles, Reactive compensation at transmission and distribution level .

CO6: evaluate the functions of various power electronic FACTS controllers 6

1. Simulation of basic transmission line model for 11KV
2. Simulation of Reactive power compensators using FACTS controllers

CO2: Demonstrate the knowledge of shunt compensators for the end of line voltage support and transient stability problems: 9

Static versus passive VAR compensator, Static shunt compensators, SVC and STATCOM, Operation and control of TSC, TCR and STATCOM Compensator control, Comparison between SVC and STATCOM.

CO7: assess the issues of damping to power system oscillations, real and reactive power control capability in power system 6

1. Load flow analysis of two-bus system with STATCOM

CO3: Analyze the operation and control of various Static Series Compensators: 9

TSSC, SSSC -Static voltage and phase angle regulators, TCVR and TCPAR Operation and Control, Applications, Static series compensation, GCSC,TSSC, TCSC and Static synchronous series compensators and their Control.

CO8: Interpret the design and working and of Power system Stabilizer. 6

1. Simulation of Thyristor Controlled Voltage Regulator
2. Simulation of Fixed Capacitor Thyristor Controlled Reactor

CO4: Demonstrate the function of Unified Power Flow Controllers: 9

Circuit Arrangement, Operation and control of UPFC, Basic Principle of P and Q control, Independent real and reactive power flow control- Applications, Introduction to interline power flow controller (IPFC).

CO9: analyse the operational aspects and their effectiveness in transient stability enhancement 6

1. Simulation of Unified Power Flow Controllers

CO5: Identify the power quality problems and demonstrate the knowledge of various types of filters and UPQC 9

harmonics, Loads that create harmonics, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filter, shunt, series, hybrid filters and their control.

Voltage swells, sags, flicker, unbalance and mitigation of these problems by unified power quality conditioner (UPQC), IEEE standards on power quality.

CO10: learn the integration in power flow analysis and their effectiveness in distribution system for harmonic mitigation 6

1. Harmonic Analysis of Power system with nonlinear load

L: 45; P: 30; TOTAL: 75 PERIODS

TEXT BOOKS:

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2nd Edition, 2016.
2. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

REFERENCES:

1. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems Modelling and Control", Springer Verlag, Berlin, 2006.
2. K.S.Sureshkumar, S.Ashok , "FACTS Controllers & Applications", Ebook edition, Nalanda Digital Library, NIT Calicut, 2003.
3. G. T. Heydt, "Power Quality", McGraw-Hill Professional, 2007.
4. T. J. E. Miller, "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982

23HE34E POWER SYSTEM OPERATION AND CONTROL L T P E C
3 0 2 0 4

COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

Theory Component

CO1:Analyze and model power systems' load frequency control.
CO2: Build the schedule and connection between the hydroelectric and thermal power plants.
CO3: Explain and resolve the various power generation economic issues
CO4: Identify and illustrate the unit commitment problem and solutions.
CO5: Describe the fundamentals of computerized electrical network management

Practical Component

CO6: Investigate and model the control area's automatic load frequency regulation**.**
CO7: Establish the load sharing between the thermal power station and the hydroelectric plant.
CO8: Showcase the unit commitment and economic dispatch issues.

CO1: Analyze and model power systems load frequency control 9

Basics of speed governing mechanism and modeling —Load Frequency Control of a single area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC-Two - area system – modeling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system.

CO6: Investigate and model the control areas automatic load frequency regulation. 8

1. Load frequency dynamics of Single Area System
2. Load Frequency dynamics of multi-area system

CO2: Build the schedule and connection between the hydroelectric and thermal power plants. 9

Hydro-thermal coordination – hydroelectric plant models - short term and long term scheduling problem – gradient approach – Hydro units in series - Hydro-thermal scheduling with pumped hydro plant: Scheduling of systems using Dynamic programming and linear programming.

CO7: Establish the load sharing between the thermal power station and the hydroelectric plant. 8

1. Short-term optimal scheduling of hydro-thermal power plant
2. Short-term optimal scheduling of hydro-thermal power plant with pumped hydro plant

CO3: Explain and resolve the various power generation economic issues. 9

Economic aspects of power generation: Load curve, load duration and integrated load duration curves – load demand, diversity, capacity, utilization and plant use factors - Statement of economic dispatch problem – cost of generation-Incremental cost curve - co-ordination equations without loss and with loss, solution by direct method and λ-iteration method.

CO8: Showcase the unit commitment and economic dispatch issues. 8

1. Economic dispatch calculation without loss using MATLAB simulink
2. Economic dispatch calculation with loss using MATLAB simulink

CO4: Identify and illustrate the unit commitment problem and solutions.

Economic load dispatch versus Unit Commitment -Statement of Unit Commitment problem – constraints, spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods – Priority list methods - forward dynamic programming approach.

CO8: Showcase the unit commitment and economic dispatch issues. 6

3. Demonstrate the unit commitment by using the priority list method.

CO5: Describe the fundamentals of computerized electrical network management. 9

Need for power system Security-Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs. Need for computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions – SCADA and EMS functions.

L: 45; P: 30; TOTAL: 75 PERIODS

TEXT BOOKS:

1. Olle. I. Elgerd, 'Electric Energy Systems theory – An introduction', McGraw Hill Education Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2. Allen. J. Wood and Bruce F. Wollen berg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 3rd Edition, 2013
3. Abhijit Chakrabarti and Sunita Halder, 'Power System Analysis Operation and Control', PHI learning Pvt. Ltd., New Delhi, 4th Edition, 2018

REFERENCES:

1. Kothari D.P. and Nagrath I.J., 'Power System Engineering', Tata McGraw– Hill Education, 2nd Edition, Reprint 2018.
2. Hadi Saadat, 'Power System Analysis', McGraw Hill Education Pvt. Ltd., New Delhi, 23rd reprint, 2015.
3. Kundur P., 'Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi, 12th reprint, 2015.

R-2023 M.E. HVE

OPEN ELECTIVE COURSES

23GD01E BUSINESS ANALYTICS L T P C
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: Understand the importance of business analytics in an organization and understand relationships between business analytics process and organization decision making process. (K1)
CO2: Study the data analytics process and issues (K2)
CO3: Study the descriptive analytics and predictive analytics for business data (K2)
CO4: Use decision-making models for formulation of decision theory. (K2)

UNIT I BUSINESS ANALYTICS 9

Overview of Business analytics- Scope of Business Analytics- Business Analytics Process- Relationship of Business Analytics Process and organization- competitive advantages of Business Analytics. Statistical Tools: Statistical Notation- Descriptive Statistical methods-Review of probability distribution and data modeling- Statistical Testing.

UNIT II DATA ANALYTICS PROCESS AND ISSUES 9

Organization/sources of data, Importance of data quality, Dealing with missing or incomplete data Data Mining Process Introduction to Data Mining, Data Classification: Decision trees, Association Analysis: Market Basket Analysis – Data mining tools.

UNIT III DESCRIPTIVE ANALYTICS 9

Introduction, Visualizing and Exploring business data, Descriptive Statistics, Sampling and Estimation: Sampling Methods, Sampling Estimation, Introduction to Probability Distributions, Marketing/Planning Case Study on Descriptive Analytics model.

UNIT IV PREDICTIVE ANALYTICS 9

Introduction, Predictive Modeling: Logic-Driven Models, Data-Driven Models, Data mining for Types of Variation in Time Series Data, Regression Model, Smoothing, Fitting models to Data, Marketing/Planning Case Study on Predictive Analytics model.

UNIT V DECISION THEORY 9

Introduction, Decision Theory Model Elements for business process, Types of Decision Environments, Decision Theory Formulation, Decision-Making Under Certainty, Decision-Making Under Risk, Decision-Making under Uncertainty, Expected Value of Perfect Information, Sequential Decisions and Decision Trees, The Value of Imperfect Information: Bayes's Theorem, Decision Theory Practice Problems.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Marc J. Schniederjans, Dara G.Schniederjans, Christopher M. Starkey, Business analytics Principles, Concepts, and Applications, Pearson FT Press, 1st Edition, 2014.
2. James R Evans, "Business Analytics", Pearson Education, 2nd Edition, 2017

23GD02E **INDUSTRIAL SAFETY** **L T P C**
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: list out important legislations related to health, Safety and Environment. (K1)
CO 2: list out requirements mentioned in factories act for the prevention of accidents. (K1)
CO 3: understand the health and welfare provisions given in factories act. (K2)
CO 4: understand the statutory requirements for an Industry on registration, license and its renewal. (K2)
CO 5: prepare onsite and offsite emergency plan. (K2)

UNIT I INTRODUCTION **9**

Industrial safety: 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 FIRE HAZARDS AND PREVENTION **9**

Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers –hydrant pipes – hoses – monitors – fire watchers – lay out of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills– notice-first aid for burns. Sprinkler-hydrants-stand pipes – special fire suppression systems like deluge and emulsifier, selection criteria of the above installations, reliability, maintenance, evaluation and standards – alarm and detection systems. Other suppression systems – CO2 system, foam system, dry chemical powder(DCP) system, halon system – need for halon replacement – smoke venting. Portable extinguishers –flammable liquids – tank farms – indices of inflammability-fire fighting systems.

UNIT III BIOLOGICAL AND ERGONOMICAL HAZARDS **9**

Classification of Biohazardous agents – examples, bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases - Biohazard control program, employee health program-laboratory safety program-animal care and handling-biological safety cabinets - building design. Work Related Musculoskeletal Disorders –carpal tunnel syndrome CTS- Tendon pain-disorders of the neck- back injuries..

UNIT IV CHEMICAL HAZARDS AND PREVENTION **9**

Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose, TLV - Methods of Evaluation, process or operation description, Field Survey, Sampling methodology, Industrial Hygiene calculations, Comparison with OSHAS Standard. Air Sampling instruments, Types, Measurement Procedures, Instruments Procedures, Gas and Vapour monitors, dust sample collection devices, personal sampling Methods of Control - Engineering Control, Design maintenance considerations, design specifications - General Control Methods - training and education

UNIT V INDUSTRIAL ACTS **9**

Statutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes,welfare, working hours, employment of young persons – special provisions – penalties and procedures-Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948, Occupational Safety and Health act of USA (The Williames - Steiger Act of 1970) – Health and safety work act (HASAWA 1974, UK) – OSHAS 18000 – ISO 14000 – American National Standards Institute (ANSI).

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Practical Industrial Safety, Risk Assessment and Shutdown Systems, 1st Edition, Dave Macdonald, Elsevier publications, 2003

2. Occupational Ergonomics: Practical Approach, Theresa Stack, Lee T.Ostrom, Cheryl A. Wilhelmsen, Wiley Publications, 2016
3. The Handbook of Safety Engineering: Principles and Applications, Frank R. Spellman and Nancy E. Whiting, Government Institutes, 2009
4. Benjamin O.Alli, “Fundamental Principles of Occupational Health and Safety”, ILO Geneva, 2nd Edition, 2008.
5. Danuta Koradecka, Handbook of Occupational Health and Safety, CRC, 2010.
6. National seminar on hazardous waste management organized by National Safety council, Ministry of environment and forests, Government of India, United States – Asia environmental partnership, Tamilnadu pollution control board and Indian chemical manufacturers association, April 2001.

Estd : 1984

23GD03E OPERATIONS RESEARCH **L T P C**
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: apply the dynamic programming to solve problems of discrete and continuous variables. (K2)
CO2: apply the concept of non-linear programming. (K2)
CO3: carry out sensitivity analysis.(K2)
CO4: model the real world problem and simulate it. (K2)

UNIT I INTRODUCTION **9**

Optimization Techniques- Model Formulation- models, General L.R Formulation- Simplex Technique-Sensitivity Analysis

UNIT II LINEAR PROGRAMMING **9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming-Transportation and Assignment problems

UNIT III NONLINEAR PROGRAMMING PROBLEM **9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT IV SCHEDULING AND INVENTORY CONTROL MODELS **9**

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

UNIT V FINITE AND INFINITE QUEUING MODELS **9**

Finite Queuing Models: Introduction, Finite Queuing Models, nfinite Queuing Models: Introduction, Queuing Theory, Operating Characteristics of a Queuing System, Constituents of a Queuing System, Service Facility, Queue Discipline

L: 45; TOTAL: 45 PERIODS

REFERENCES

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

23GD04E COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: Students should able to apply the dynamic programming to solve problems of discreet and continuous variables. (K1)

CO2: Students should able to apply the concept of non-linear programming Students should able to carry out sensitivity analysis. (K2)

CO 3: Student should able to model the real world problem and simulate(K2)

UNIT 1 **9**

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

UNIT II **9**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project

UNIT III **9**

Execution: conception to commissioning. Project execution as conglomeration of technical and non-technical 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.Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

UNIT IV **9**

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.Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector.Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints.Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets.Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT V **9**

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory

L: 45;TOTAL: 45 PERIODS

REFERENCES

1. Charles T. Horngren, Srikant M. Datar, “Cost Accounting A Managerial Emphasis”, Prentice Hall of India, 14th Edition,New Delhi. 2011
2. Charles T. Horngren and George Foster,“Advanced Management Accounting”. Pearson Education India; 16th Edition,2013.
3. Ashish K. Bhattacharya, “Principles & Practices of Cost Accounting” A. H. Wheeler publisher,Delhi
4. N.D. Vohra,” Quantitative Techniques in Management”, Tata McGraw Hill Book Co. Ltd.

23GD05E COMPOSITE MATERIALS L T P C
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: Identify, describe and evaluate the properties of fibre reinforcements polymermatrix materials and commercial composites. (K1)

CO 2: Develop competency in one or more common composite manufacturingtechniques, and be able to select the appropriate technique for manufactureof fibre-reinforced composite products.(K1)

CO 3: Analyse the elastic properties and simulate the mechanical performance of composite laminates; and understand and predict the failure behaviour of fibre-reinforced composite products. (K2)

CO 4: Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project.(K2)

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials. Advantages and application of composites- Types of reinforcements and matrices-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 DESIGN AND ANALYSIS OF COMPOSITE MATERIALS 9

Strength: 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.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Mechanics of Composite Materials, Autor K Kaw,Taylor & Francis, 2nd Edition, 2006
2. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany,1993
3. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R.Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

23GD06E **WASTE TO ENERGY** **L T P C**
3 0 0 3

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: analyze the various aspects of Waste to Energy Management Systems (K2)
CO2: understand biochemical conversion of biomass for energy application, bioenergy systems and process integration.(K2)
CO3: understand the management of e-waste (K2)

UNIT I INTRODUCTION TO WASTE AND WASTE PROCESSING 9

Solid waste sources solid waste sources, types, composition, properties, global warming; Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, segregation of waste, size reduction, managing waste, status of technologies for generation of energy from waste treatment and disposal aerobic composting, incineration, furnace type and design, medical waste / pharmaceutical waste treatment technologies, incineration, environmental impacts, measures to mitigate environmental effects due to incineration

UNIT II WASTE TRATMENT AND DISPOSAL 9

Land fill method of solid waste disposal land fill classification, types, methods and sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leach ate and gases, environmental monitoring system for land fill gases.

UNIT III BIO-CHEMICAL CONVERSION 9

Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel. Industrial waste, agro residues and anaerobic digestion.

UNIT IV THERMO-CHEMICAL CONVERSION 9

Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo- chemical conversion.

UNIT V E- WASTE MANAGEMENT 9

E-waste: E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; Recycling e-waste: A thriving economy of the unorganized sector, global trade in hazardous waste, impact of hazardous e-waste in India; Management of e-waste: E-waste legislation, government regulations on e-waste management, international experience, need for stringent health safeguards and environmental protection laws of India.

L: 45; TOTAL: 45 PERIODS

REFERENCES

1. Nicholas P Cheremisinoff, “Handbook of Solid Waste Management and Waste Minimization Technologies”, An Imprint of Elsevier, New Delhi, 2003.
2. Paul Breeze, “Energy from Waste”, An Imprint of Elsevier, New Delhi, 2018.
3. P Aarne Vesilind, William A Worrell and Debra R Reinhart, “Solid Waste Engineering”, 2nd Edition 2002.
4. C Parker and T Roberts (Ed), “Energy from Waste”, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
5. KL Shah, “Basics of Solid and Hazardous Waste Management Technology”, Prentice Hall, Reprint Edition, 2000.
6. M Datta, “Waste Disposal in Engineered Landfills”, Narosa Publishing House, 1997.

R-2023 M.E. HVE

AUDIT COURSES

23AC01E **TECHNICAL REPORT WRITING**

L	T	P	C
2	0	0	0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Enhance the knowledge of the research objectives and research process
CO2: Develop the level of readability for formulating rationale and improve writing skills
CO3: Formulate suitable sentences and key words for the research paper
CO4: Develop the skill of chapterisation and research writing
CO5: Interpretation of data through various strategies
CO 6: Implementation of basic rules and methods of citation

INTRODUCTION TO RESEARCH **5**

Research – Writing Definitions – Framing Objectives – Research process - Formulating Research problem – Technical terms and extended definition - Breaking up long sentences--structuring paragraphs and sentences - being concise and removing redundancy avoiding ambiguity and vagueness.

IDENTIFICATION & COLLECTION OF SOURCES **5**

Preparing manuscript – Skimming and Scanning – Review of literature- Identifying the problem - writing problem statements – writing hypothesis- Formulating Rationale – Research Design - linking phrases – Observation and Interview method – Framing Questionnaire – Case study

WRITING AND DRAFTING ABSTRACT **5**

Processing and data analysis – Identifying threats and challenges to Good Research - key skills needed to write a title - writing abstracts writing key words and introduction- Introductory phrases - Clarity in imperative sentences instruction writing – useful phrases to draft a perfect paper

CHAPTERISATION **5**

Main divisions and Subdivisions – Paragraph writing - coherence - Highlighting the findings - Analyzing Data collection - hedging and criticizing sections - Topic sentence --Paraphrasing and framing key points – Suitable section wise headings

INTERPRETATION OF DATA **5**

Non-verbal interpretation – Interpretation of Data - Abbreviations – Symbols Tables – graphs – charts - deriving result – Phrases used to Compare and Contrast -result and discussion-- skills needed to write the conclusions – avoiding common mistakes.

BIBLIOGRAPHY **5**

Citation methods – Writing Foot note – End note - bibliography – citation rules Basic reference format - plagiarism – acknowledgement – IEEE Research format – Research review Research paper Publication

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Brent, Doug. Reading as Rhetorical Invention: Knowledge, Persuasion, and the Teaching of Research-based Writing. Urbana, National Council of Teachers of English, 1992.
2. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht, 2016
3. Robert A. Day and Barbara Gastel, How to Write and Publish a Scientific Paper‖, Cambridge University Press, 7th Edition, 2012
4. Thiel, David V. Research Methods for Engineers. United Kingdom, Cambridge University Press, 2014.

23AC02E **DISASTER MANAGEMENT**

L	T	P	C
2	0	0	0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and manitarian response.

CO2: Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO3: Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO4. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

INTRODUCTION **4**

Disaster: Definition- Factors and Significance- Difference Between Hazard and Disaster- Natural and Manmade Disasters: Difference-Nature- Types And Magnitude.

REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage: Loss Of Human And Animal Life, Destruction Of Ecosystem-Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches- Man-made disaster- Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

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.

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.

RISK ASSESSMENT AND DISASTER MITIGATION **8**

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. Meaning: Concept and Strategies Of Disaster Mitigation-Emerging Trends In Mitigation-Structural Mitigation and Non-Structural Mitigation-Programs of Disaster Mitigation In India.

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Singhal J.P. —Disaster Managementǁ, Laxmi Publications, ISBN-10: 9380386427 ISBN-13: 978-9380386423, 2010
2. Tushar Bhattacharya, —Disaster Science and Managementǁ, McGraw Hill India Education Pvt. Ltd., ISBN-10: 1259007367, ISBN-13: 978-125900736, 2012.
3. Gupta Anil K, Sreeja S. Nair, "Environmental Knowledge for Disaster Risk Management", NIDM, New Delhi, 2011.
4. Kapur Anu, "Vulnerable India: A Geographical Study of Disasters", IIAS and Sage Publishers, New Delhi, 2010.

5. National Disaster Management Plan, 2018, https://ndma.gov.in/images/pdf/NDMP-2018-Revised-Draft-1-2018OCT16-A.pdf
6. National Disaster Management Authority, Government of India, 2018, https://ndma.gov.in/images/pdf/Draft-Guidelines-thunderstorm-final.pdf

23AC03E SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Learn the Sanskrit sources of technical knowledge
CO2: Drawing their attention to a different dimension of Sanskrit literary tradition
CO3: Create awareness of the contemporary relevance of the Sanskrit sources of traditional wisdom

INTRODUCTION 7

Scope and meaning of study of technical literature in Sanskrit. Different disciplines-interdisciplinary approach-dimensions-contemporary relevance- important works in this direction-scientific methodology in ancient India.

AYURVEDA 7

Beginnings of Ayurveda in Atharvaveda-Ayurvedic literature-basic principles of Ayurveda-Pancabhutasiddhanta-Tridosasiddhanta-eight anga-s of Ayurveda- Rasacikitsa-contribution of Kerala to Ayurveda

ASTRONOMY AND MATHEMATICS 8

Major texts in Vedic and classical period-Vedangajyotisa-Sulbasutra-s-Aryabhatiya- Aryabhata's contribution-Varahamihira-Brahmagupta-Lalla-etc. Suryasiddhanta- Kerala school Parahita and drk systems-Later astronomical works commentaries.

VASTUSASTRA AND ARTHASASTRA 8

Principles of Vastusastra-Basic texts-Vastuvidya and Ecology-Iconography and sculpture-Kerala tradition of Vastusastra. Arthasastra, a historical and sociaological perspective-structure and contents of the text-emphasis to aspects of agriculture and architecture.

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Ramakrishna Mission Institute ,"Cultural Heritage of India", (Vol. i and iii), Calcutta, 2010
2. Dr.P.C. Muraleemadhavan and Dr.N.K.Sundareswaran," Sanskrit in Technological Age,(Ed.)", New Bharatiya Book Corporation, Delhi, 2006
3. https://sanskritdocuments.org/articles/ScienceTechSanskritAncientIndiaMGPrasad.pdf
4. http://www.vedanta.gr/wp-content/uploads/2012/03/3_GlossaryOfCommonSanskrit Terms.pdf

23AC04E VALUE EDUCATION L T P C
2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Understand the need of values and its classification in contemporary society
CO2: Become aware of role of education in building value as dynamic social reality.

CO3: Know the importance of value education towards personal, national and global development.

10

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

10

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 brotherhood and religious tolerance-True friendship-Happiness Vs suffering- love for truth-Aware of self-destructive habits-Association and Cooperation- Doing best for saving nature.

10

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.

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Sharma, S.P., "Moral and Value Education: Principles and Practices", Kanishka publishers, 2013.
2. Kiruba Charles & V.Arul Selvi.," Value Education", Neelkamal Publications, New Delhi, 2012.
3. Passi, B.K. and Singh, P.,"Value Education", National Psychological Corporation, Agra. 2004.
4. http://cbseportal.com/exam/e-books/download-free-ncert-e-book-education-for-values-in-school-a-framework/
5. http://cbseacademic.in/web_material/ValueEdu/Value%20Education%20Kits.pdf

23AC05E CONSTITUTION OF INDIA L T P C
2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.

CO2: address the growth of Indian opinion regarding modern Indian intellectuals constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

CO3: address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

HISTORY AND PHILOSOPHY OF INDIAN CONSTITUTION 6

History-Drafting Committee, (Composition & Working). - Preamble- Salient Features.

CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES 6

Fundamental Rights - Right to Equality-Right to Freedom - Right against Exploitation - Right to Freedom of Religion - Cultural and Educational Rights - Right to Constitutional Remedies - Directive Principles of State Policy- Fundamental Duties.

ORGANS OF GOVERNANCE **6**

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

LOCAL ADMINISTRATION **6**

District's Administration head: Role and Importance- Municipalities: Introduction, Mayor and role of Elected Representative-CEO of Municipal Corporation-Pachayati raj: Introduction, PRI:ZilaPachayat- Elected officials and their roles,-CEO ZilaPachayat: Position and role- Block level: Organizational Hierarchy (Different departments)-Village level: Role of Elected and Appointed officials- Importance of grass root democracy.

ELECTION COMMISSION **6**

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

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Subhash .C, kashyap "Our Constitution", 5th Edition, 2017
2. www.ieagreements.org/IEA-Grad-Attr-Prof-Competencies.pdf
3. The Constitution of India, 1950 (Bare Act), Government Publication.
4. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
5. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
6. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

23AC06E **PEDAGOGY STUDIES** **L T P C**
2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: Describe the pedagogical practices used by teachers in formal and informal classrooms

CO2: Understand the effectiveness of these pedagogical practices, in what conditions, and with what population of learners

CO3: Analyze how teacher education (curriculum and practicum) and the school curriculum with guidance materials support effective pedagogy

INTRODUCTION AND METHODOLOGY **8**

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

EFFECTIVENESS OF PEDAGOGICAL PRACTICES **8**

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

PROFESSIONAL DEVELOPMENT **7**

Alignment with classroom practices and follow-up support- Peer support-Support from the head teacher and the community-Curriculum and assessment-Barriers to learning: limited resources and large class sizes.

RESEARCH GAPS AND FUTURE DIRECTIONS **7**

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

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Dr.S.K.Bhatia and Dr.Sonia Jindal, “A Text Book of Curriculum, Pedagogy and Evaluation”, Paragon International Publications, 2016.
2. Ackers J, Hardman F Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261, 2001.
3. Agrawal M, "Curricular reform in schools: The importance of evaluation", Journal of Curriculum Studies, 36 (3): 361-379, 2004.
4. Akyeampong K, "Teacher training in Ghana - does it count?", Multi-site teacher education research project (MUSTER) country report 1. London: DFID, 2003.
5. Akyeampong K, Lussier K, Pryor J, Westbrook J, "Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?", International Journal Educational Development, 33 (3): 272–282,2013.
6. Alexander RJ,"Culture and pedagogy: International comparisons in primary education", Oxford and Boston: Blackwell, 2001.
7. Chavan M, "Read India: A mass scale, rapid, ‘learning to read’", campaign, 2003.
8. www.pratham.org/images/resource%20working%20paper%202.pdf.

23AC07E STRESS MANAGEMENT BY YOGA **L T P C**
2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: achieve overall health of body and mind

CO2: overcome stress

INTRODUCTION **10**

Introduction to Stress-Concept of Stress-Solutions through Mandukya karika - Relaxation and stimulation combined as the core for stress management-Practice of Stimulation and relaxation.

ASAN AND PRANAYAM **10**

Definitions of Eight parts of yoga. (Ashtanga)-Various yoga poses and their benefits for mind & body-Regularization of breathing techniques and its effects-Types of pranayam.

YOGA AND STRESS MANAGEMENT **10**

Concepts and Techniques of Stress Management in Ashtanga Yoga of Patanjali - specific practices for stress management-breathe awareness.

L: 30; TOTAL: 30 PERIODS

REFERENCES

1. Swami Vivekananda, Advaita Ashrama ,“Rajayoga or conquering the Internal Nature”, 2016.

2. K.N.Udupa**,** **"**Stress and Its Management by Yoga", Edited by R.C.Prasad, Motilal Banarashidass Publishers, Delhi, 2010.
3. Lisa Shea,"Yoga for Stress Relief and Forgiveness", Kindle Edition, 2015.
4. BKS Iyengar, "Yoga: The path to Holstic Health", DK Publication, 2019
5. https://www.longdom.org/open-access/stress-and-yoga-2157-7595.1000109.pdf

23AC08E	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

COURSE OUTCOMES

Upon completion of this course, the student will be able to

CO1: learn to achieve the highest goal happily

CO2: become a person with stable mind, pleasing personality and determination (K1)

CO3: awaken wisdom in students

INTRODUCTION TO PERSONALITY DEVELOPMENT **10**

The concept of personality - Dimensions of personality – Theories of Freud & Erickson- Significance of personality development. The concept of success and failure: What is success? - Hurdles in achieving success - Overcoming hurdles - Factors responsible for success – What is failure - Causes of failure-SWOT analysis.

LIFE ENLIGHTENMENT SKILLS **10**

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).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.

SHRIMAD BHAGWAD GEETA STATEMENTS **10**

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, Chapter3 Verses 36, 37, 42, Chapter4 Verses 18, 38,39, Chapter18 Verses 37,38,63

L: 30; TOTAL: 30 PERIODS

REFERENCES

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