Course Structure and Syllabus AY 2019-20

Bachelor of Technology in Electrical Engineering and Master of Technology in Power System Engineering

DEPARTMENT OF ELECTRICAL ENGINEERING

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA,

BURLA – 768018

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, BURLA, ODISHA

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To be recognized as a centre of excellence in education and research in the field of Electrical Engineering by producing innovative, creative and ethical Electrical Engineering professionals for socio-economic development of society in order to meet the global challenges.

MISSION

Electrical Engineering Department of VSSUT Burla strives to impart quality education to the students with enhancement of their skills to make them globally competitive through:

M1. Maintaining state of the art research facilities to provide enabling environment to create, analyze, apply and disseminate knowledge.

M2. Fortifying collaboration with world class R&D organizations, educational institutions, industry and alumni for excellence in teaching, research and consultancy practices to fulfil ‘Make in India’ policy of the Government.

M3. Providing the students with academic environment of excellence, leadership, ethical guidelines and lifelong learning needed for a long productive career.

PROGRAM EDUCATIONAL OBJECTIVES

The program educational objectives of Dual Degree in Electrical Engineering with specialization in Power System Engineering program of VSSUT Burla are to prepare its graduates:

1. To have sound knowledge of basic concepts of electrical engineering and advanced concepts of power system engineering including analysis, design and modelling of electrical systems with focus on power system components by using the latest available tools.
2. To excel in their professional career/entrepreneurial skill/research and higher studies and lead in the conception, design and implementation of new products, processes, services and systems according to the prevailing socio-economic context.
3. To augment the specialized workforce in the electrical engineering domain requiring advanced knowledge of power system engineering in private, government and public sector industries, educational institutions and state-of-the-art research laboratories.

PROGRAM OUTCOMES for Dual Degree (EE-PSE)

PO1	An ability to independently carry out research/investigation and development work to solve practical electrical engineering problems with emphasis on power system engineering.
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4	An ability to create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex problems in power system engineering with an understanding of the limitations.
PO5	An ability to understand of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research in electrical engineering with focus on power systems.
PO6	Demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis to further the learning of themselves as well as others.

Program Specific Outcomes for Dual Degree (EE-PSE)

PSO1	Ability of design, modelling and analysis of electrical systems and specifically power system components using the latest available tools.
PSO2	Develop suitable techniques and cutting-edge engineering hardware and software to solve problems in electrical systems with focus on power system engineering.

COURSE STRUCTURE

COURSE STRUCTURE FIRST YEAR		FIRST SEMESTER (THEORY)		
Sl.No	**Course Code**	**Subject**	**Contact Hrs. L-T-P**	**Credits**
1	BMA01001	Mathematics-I	3-1-0	4
2	BPH01001	Physics	3-0-0	3
3	BEE01001	Basic Electrical Engg.	3-0-0	3
4	BHU01001	English For Business Communication	3-0-0	3
5	BME01001	Engineering Mechanics	3-0-0	3
		SESSIONALS		
1	BPH01002	Physics Laboratory	0-0-3	1.5
2	BEE01002	Basic Electrical Engg. Lab	0-0-3	1.5
3	BHU01002	Business Communication Skills	0-0-3	1.5
4	BME01002	Workshop & Manufacturing Practices	0-0-3	1.5
		NON-CREDIT		
1	BNC01001	Induction Programme and participation in Clubs/Societies	0-0-0	0
		Total	15-1-12	22

COURSE STRUCTURE FIRST YEAR		SECOND SEMESTER (THEORY)		
Sl.No.	**CourseCode**	**Subject**	**Contact Hrs. L-T-P**	**Credits**
1	BMA02001	Mathematics - II	3-1-0	4
2	BCH02001	Chemistry	3-0-0	3
3	BEC02001	Basic Electronics	3-0-0	3
4	BIT02001	Programming for Problem Solving	3-0-0	3
5	BME02001	Basic Civil Engg.	3-0-0	3
		SESSIONALS		
1	BCH02002	Chemistry Lab	0-0-3	1.5
2	BEC02002	Basic Electronics Lab	0-0-3	1.5
3	BIT02002	Programming Lab /	0-0-3	1.5
4	BCE02002	Engineering Graphics & Design	0-0-3	1.5
		NON-CREDIT		
1	BNC02001	NSS/NCC/Yoga	0-0-0	0
		Total	15-1-12	22

*** This contact hour is beyond the regular time table teaching.**

COURSE STRUCTURE THIRD SEMESTER SECOND YEAR (THEORY)				
Sl.No	**CourseCode**	**Subject**	**Contact Hrs. L-T-P**	**Total Credits**
1	BMA03001	Math-III	3-1-0	4
2	BEE03001	Electrical Machines-I	3-0-0	3
3	BEE03002	Network Theory	3-0-0	3
4	BEE03003	Instrumentation and Sensors	3-0-0	3
5	BHU03001	Organisational Behaviour	3-0-0	3
SESSIONAL				
1	BEE03004	Electrical Machines Lab-I	0-0-3	1.5
2	BEE03005	Network Lab.	0-0-3	1.5
3	BEE03006	Electrical Computational Lab	0-0-3	1.5
4	BEE03007	Instrumentation Lab	0-0-3	1.5
NON-CREDIT				
1	BNC03001	Essence of India Traditional Knowledge/ Environmental Sciences	2-0-0*	0
TOTAL			15-1-12	22

COURSE STRUCTURE FOURTH SEMESTER SECOND YEAR (THEORY)				
SI. No	**Course Code**	**Subject**	**Contact Hrs. L-T-P**	**Credit**
1	BEE04001	Electrical Machines-II	3-0-0	3
2	BEE04002	Electric Power Generation Systems	3-0-0	3
3	BEE04003	Analog and Digital Electronic Circuits	3-0-0	3
4	BMA04001	Math-IV	3-1-0	4
5	BHU04001	Economics for Engineers	3-0-0	3
SESSIONALS				
6	BEE04003	Electrical Machines Lab-II	0-0-6	3
7	BEE04004	Analog and Digital Electronic Circuits Lab	0-0-6	3
NON-CREDIT				
1	BNC04001	Environmental Sciences/ Essence of India Traditional Knowledge	2-0-0*	0
2	BNC04002	Summer Internship/ Training/ Project	0-0-0	0
Total			15-1-12	22

*** This contact hour is beyond the regular time table teaching.**

COURSE STRUCTURE THIRD YEAR		FIFTH SEMESTER (THEORY)		
SI. No	**Course Code**	**Subject**	**Contact Hrs. L-T-P**	**Credit**
1	BEE05001	Electrical Power Transmission & Distribution	3-0-0	3
2	BEE05002	Control System-I	3-0-0	3
3	BEE05003	Power Electronics	3-0-0	3
4		Professional Elective -I	3-0-0	3
5		Open Elective -I	3-0-0	3
6		Professional Ethics, Professional Law & Human Values / Financial Management, Costing, Accounting, Balance Sheet & Ratio Analysis	2-0-0	2
		SESSIONAL		
1	BEE05004	Control System Lab	0-0-3	1.5
2	BEE05005	Power Electronics Lab.	0-0-3	1.5
3	BEE05006	Signal & System lab	0-0-3	1.5
		Total	17-0-9	21.5

COURSE STRUCTURE THIRD YEAR		SIXTH SEMESTER (THEORY)		
SI. No	**Course Code**	**Subject**	**Contact Hrs. L-T-P**	**Credit**
1	BEE06001	Switchgear & Protection	3-0-0	3
2	BEE06002	Microprocessor & Microcontroller	3-0-0	3
3		Professional Elective -II	3-0-0	3
4		Professional Elective-III	3-0-0	3
5		Open Elective-II	3-0-0	3
6		Financial Management Costing, Accounting, Balance Sheet & Ratio Analysis/ Professional Ethics, Professional Law & Human Values	2-0-0	2
		SESSIONALS		
1	BEE06003	Microprocessor & Microcontroller Lab	0-0-3	1.5
2	BEE06004	Power System Lab-I	0-0-3	1.5
3	BEE06005	Electrical Machine Design	0-0-3	1.5
		NON-CREDIT		
1	BNC06001	Summer Internship/ Training/ Project	0-0-0	0
		Total	17-0-9	21.5

List of Professional Elective (Fifth and Sixth Semester)			
Sl. No.	Category	Course Code	Subject Name
1	Professional Elective-I	BEEPE501	Signal & Systems
2		BEEPE502	Electromagnetic Field Theory
3		BEEPE503	Industrial Power Electronics
4		BEEPE504	Renewable Energy Sources
1	Professional Elective -II	BEEPE601	Control System-II
2		BEEPE602	Digital Circuit Design
3		BEEPE603	Embedded System
4		BEEPE604	Computer System Architecture
1	Professional Elective-III	BEEPE605	Drives & Traction
2		BEEPE606	Engineering Optimization
3		BEEPE607	Heuristic Optimization
4		BEEPE608	Sensor Technology

COURSE STRUCTURE FOURTH YEAR		SEVENTH SEMESTER (THEORY)		
SL NO	COURSE CODE	SUBJECT	CONTACT HRS L-T-P	CR
1	BEE07001	Power System Operation and Control	3-0-0	3
2	BEE07002	High Voltage Engineering	3-0-0	3
3	BEE07003	Power System Analysis	3-0-0	3
4	BEE07004	Operation and Control of Restructured Power Systems	3-0-0	3
5	Common	Research Methodology & IPR	3-0-0	3
SESSIONALS				
1	BEE07005	Power System Lab-I	0-0-6	4
2		Seminar on Internship	0-0-3	1
2		Audit-1		
TOTAL			15-0-9	20

COURSE STRUCTURE FOURTH YEAR		EIGHTH SEMESTER (THEORY)		
SL NO	COURSE CODE	SUBJECT	CONTACT HRS L-T-P	CR
1	BEE08001	Power System Dynamics	3-0-0	3
2	BEE08002	Reliability of Power Systems	3-0-0	3
3		Professional Elective-IV	3-0-0	3
4		Professional Elective-V	3-0-0	3
SESSIONALS				
1	Common	Minor project & Seminar	0-0-3	2
2	BEE08003	Power System Lab-II	0-0-6	4
3		Audit-2		
TOTAL			15-0-9	18

NINTH SEMESTER

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	PPE		Professional Elective-VI	3	0	0	3
2	OE-1		Open Elective - III	3	0	0	3
3	Minor Project		Dissertation (Phase-I)	0	0	20	10
Total Credits							16

TENTH SEMESTER

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Major Project		Dissertation (Phase-II)	0	0	32	16
Total Credits							16

Total credits: **201**
Division: UG credits: **138 (83% of B.Tech. in EE)**; PG credits: **63(91% of M.Tech. in PSE)**

List of Professional Elective (Fourth and Fifth Year)			
Sl. No.	Category	Course Code	Subject Name
1	Professional Elective -IV (PG)	BEEPE801	Digital Protection of Power Systems
2		BEEPE802	Wide area monitoring and control
3		BEEPE803	Advanced Digital Signal Processing
4		BEEPE804	Wireless Sensor Networks
1	Professional Elective -V (PG)	BEEPE805	FACTS and Custom Power Devices
2		BEEPE806	Power Electronic Converters
3		BEEPE807	Industrial Automation and Control
4		BEEPE808	Industrial Load Modeling and Control
1	Professional Elective -VI (PG)	BEEPE901	Power System Optimization
2		BEEPE902	Smart Power Grids
3		BEEPE903	Forecasting Methods in Power System
4		BEEPE904	Nonlinear Dynamics

DETAILED SYLLABI

IST SEMESTER

THEORY

Mathematics-I (Calculus andLinearAlgebra)

Module 1: Calculus (8 Lectures)

Rolle's theorem, Mean value theorems(statements only) and applications. Introduction to improper integrals. Beta and Gamma functions and their properties.

Module 2: Calculus (8 Lectures)

Convergence of sequence and series, tests of convergence. Fourier series, arbitrary period, even and odd function, half range series.

Module3: Calculus (8Lectures)

Limit, continuity and partial derivatives (two variables), maxima and minima. Vector and scalar point functions and fields, gradient of a scalar field, directional derivative, divergence of a vector field, curl of a vector field andapplications

Module 4: Linear Algebra *(8 Lectures)*

Linear systems of equations, Gauss elimination, linear independence, rank of a matrix, Gauss-Jordan elimination. Vector Space; basis and dimension'

Module 5: Linear Algebra*(8 Lectures)*

Eigen values, eigenvectors, some applications of eigenvalue problems, symmetric, skew-symmetric and orthogonal matrices, diagonalization, quadratic forms, complex matrices and forms.

Text Book:

1) Erwin Kreyszig, Advanced Engineering Mathematics (9^{th} Edition), Wiley India Pvt.Ltd
2) S.C. Malik and S. Arora, Mathematical Analysis, New AgeInternational

Reference Books:

1) George B. Thomas, Jr. and Ross L. Finney, Calculus and Analytic Geometry, Addison Wesley PublishingCompany
2) B.V. Ramana, Higher Engineering Mathematics, McGrawHill
3) A. Stroud, Advanced Engineering Mathematics, IndustrialPress

4) S.K. Paikray, Text book of Matrix Algebra, KalyaniPublisher

COURSE OUTCOMES:

CO1: To acquire basic knowledge of differential calculus and improper integral and have a basic understanding of Beta and Gamma functions useful in various fields

CO2: To develop a tool of Fourier series understanding the periodic phenomenon for learning advanced Engineering mathematics.

CO3: To deal with functions of several variables that is essential in most of the branches of engineering.

CO4: To understand Gauss elimination method and rank of a matrix in solving linear equations. CO5: To experience the knowledge of eigenvalues and eigenvectors in a comprehensive manner.

ENGINEERING PHYSICS

MODULE-I:
PROPERTIES OF MAITER: Idea of elastic constants (Y, K, η and σ), relation between elastic constants, torsion pendulum, determination of η, Cantilever at one end.

MODULE-II:
OSCILLATION AND WAVES: Review of Simple Harmonic Oscillation and application to compound pendulum, Damped harmonic oscillation, Forced oscillation, Resonance, (Amplitude resonance, Velocity resonance, Sharpness of resonance).

MODULE-III:
OPTICS: Concept of wave and wave equation, Superposition of many harmonic waves. Interference, Concept of coherent Sources (Division of wave front and division of amplitude) Interference in thin parallel film, Newton's ring (Theory, Application: Determination of wavelength of light, Refractive index of liquid).Concept of diffraction (Huygen's principle), types of diffraction, Franhoffer diffraction due to single slit and diffraction grating. Determination of wavelength, Dispersive power and resolving power of plane diffraction grating, Polarisation: Double refraction, Half 'Wave plate and quarter wave plate.

MODULE-IV:
ELECTROMAGNETISM: Vector Calculus: Gradient, Divergence, Curl (Mathematical concept), Gauss divergence theorem and Stoke's theorem (statements only), Derivation of Maxwell's electromagnetic equation in differential form and in integral form, Electromagnetic wave equations for E and B in vacuum and conducting medium, transverse nature of EM waves.

MODULE-V:

QUANTUM PHYSICS & PHOTONICS: Wave particle duality, Matter waves (de Broglie Hypothesis),Wave functions, Observable as Operators, Eigen function and Eigen values, Normalization, Expectation values, Schrodinger equation (Time dependent and time independent),Pa1ticle in a box.

LASERS: Introduction, Characteristics of lasers, Einstein's coefficients &Relation between them, Lasing action (Population inversion, Three and Four level pumping schemes), Different types of Lasers (Ruby Laser, He-Ne Laser).

Text Books:

Principles of Engg. Physics; Md. N. Khan and S. Panigrahi

Engg. Physics: H. K. Malik and A. K .Singh

Reference Books:

Oscillation and waves: N. Subrahmanyam and BrijLal

Optics-A.K. Ghatak

Electrodynamics by: D. J. Griffith

Concepts of Modern Physics-A. Beiser

Lasers, Theory and Applications-K. Thyagarajan and A.K.Ghatak

BASIC ELECTRICAL ENGINEERING

MODULE-I (8 HOURS)

D.C circuit analysis and network theorems: Concept of network, Active and passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements, source transformation, Kirchoff's Law: loop and nodal methods of analysis, star delta transformation, network theorems: Thevenin’s theorem, Norton’s theorem, maximum power transfer theorem. Transients, in R-L, R-C and R-L-C circuits with DC Excitation.

MODULE-II (8 HOURS)

Single phase and three phase ac circuit: Sinusoidal, square and triangular waveforms-average and effective value, form the peak factors, concept of phasors, phasors representation of sinusoidally varying voltage and current, analysis of series-parallel RLC circuits. Apparent, active and reactive powers, power factor, power factor improvement, resonance in series and parallel circuits, bandwidth and quality factors, star and delta connections, balanced supply and balanced load, line and phase voltage/current relation, three phase power measurements.

MODULE-III (8 HOURS)

Magnet circuit & principle of electromechanical energy conversion: Analogy between electric and magnetic circuit, magnetic circuits with DC and AC excitation, magnetic leakage, BH curve, hysteresis and eddy current losses, magnetic circuit calculation, mutual coupling.

Principles of dc motor & generator, types, emf equation of DC machine, torque equation of motor, Speed control of dc motor. characteristics and applications of DC motors.

MODULE-IV (8 HOURS)

AC MACHINES: Single Phase Transformer: Principle of operation, construction, emf equation, equivalent circuit, power losses, efficiency, Introduction to auto transformers. Three Phase Induction Motor: Type, principle of operation, slip-torque Characteristics, applications. Single Phase Induction Motor: Principle of operation and introduction to methods of starting, applications. Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor, emf equation, voltage regulation, applications.

MODULE-V (7 HOURS)

Measurement Instruments & Introduction to Power System: Types of instruments: construction and working principle of PMMC and MI type voltmeter and ammeters, single phase dynamometer type wattmeter and induction type energy meter, use of shunts and multipliers: general layout of electrical power system and function of its elements, concept of grid, Introduction to power converters.

TEXT BOOKS

[1]. Edward Hughes (revised by Ian McKenzie Smith), “Electrical & Electronics Technology”, Pearson Education Limited. Indian Reprint 2002, 10th Edition.

[2]. D.Kulshreshtha, “Basic Electrical Engineering” TMH, 1st Edition.

REFERENCE BOOKS

[1]. C.L. Wadhwa, “Electrical Engineering”, New Age International Publishers, 2nd Edition.

[2]. S. Parker Smith, “Problems in Electrical Engineering”, Asia Publications, 10th Edition.

Course Outcomes:

Upon completion of the subject the students will demonstrate the ability to:

CO1	Implement principles of DC network, theorems and transients.
CO2	Analyze the concept of Single phase and three phase AC circuits.
CO3	Express the concept of magnetic circuit and DC machines.
CO4	Apply basic principles of AC machines and their working.
CO5	Demonstrate basic principles of measuring instruments and power system.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

English for Business Communication

Syllabus:

Objective - For developing the ability to communicate effectively in Corporate environment by enhancing their skills in communication.

Module 1: Fundamentals of Communication (6 Hours)

- Process of Communication, Types of Communication (Verbal & Non Verbal)
- Channels of Business Communication
- Barriers to Communication.
- Plain English
- Bias free language
- Cross Cultural Communication

Module 2: Communicative Grammar (06 Hours)

- Time and Tense
- Aspects (Perfective & Progressive)
- Verbs of State and Event
- Passive and Active Voice
- Conditionals

Module 3: Sounds of English (06 Hours)

- The Speech Mechanism and Organs of Speech
- ConsonantSounds of English
- Vowel Sounds of English
- Stress Pattern: Syllable, Stress and Intonation.
- Problem sounds for Indian Speakers

Module 4: Business Writing (06 Hours)

- Paragraph writing
- Sentence Linker
- Business Letters
- Report Writing
- Proposal writing

Module 5: Professional Writing (06 Hours)

- Notice, Circular and Memo writing
- Agenda & Minute writing
- Writing Cover letter
- Résumé (CV) Writing

Text Books:

1. Effective Technical Communication by M Ashraf Rizvi (Tata McGraw Hill)
2. Business Communication by HorySankerMukerjee (Oxford University Press)
3. Better English Pronunciations By J. D.O Conner (Cambridge University Press)
4. A Communicative Grammar of English by G.N. Leech and Jan Svartik (OUP)

   Reference Books: “Business communication” by Ramachandran, Lakshmi and Krishna (Macmillan)

ENGINEERING MECHANICS

Course Objectives:

- Solve the engineering problems in case of equilibrium conditions.
- Importance of frictional force in real world problems.
- Concept of centre of gravity and moment of inertia.
- Principle of work and energy and conservation of momentum
- Analyze the motion and calculate trajectory characteristics.

Course Contents:

Module - I (8 Hours)

Concurrent forces on a plane: Composition, resolution and equilibrium of concurrent coplanar forces, method of moment.

General case of forces on a plane: Composition and equilibrium of forces in a plane, plane trusses, method of joints and method of sections, plane frame, equilibrium of ideal systems.

Module-II (8 Hours)

Friction: Problems involving dry friction, Ladder, Wedges

Principle of virtual work.

Module - III (8 Hours)

Parallel forces on a plane: General case of parallel forces, center of parallel forces and center of gravity, centroid of composite plane figure and curves, Theorems of Pappus.

Moments of inertia: Plane figure with respect to an axis in its plane and perpendicular to the plane, Polar moment of inertia, parallel axis theorem

Module – IV (8 Hours)

Rectilinear translation: Kinematics, principle of dynamics, D Alembert’s Principle,

Principle of work and energy for a particle and a rigid body in plane motion, Conservation of energy, Principle of impulse and momentum for a particle and a rigid bodies in plane motion, Conservation of momentum, System of rigid bodies, Impact, direct and central impact, coefficient of restitution.

Module – V (8 Hours)

Curvilinear translation: Kinematics, equation of motion, projectile, D Alembert’s principle of curvilinear motion.

Kinematics of rotation of rigid body.

Text Book:

1. Engineering Mechanics: S Timoshenko & Young; 4th Edition (International edition) Mc Graw Hill.

Reference Books:

1. Fundamental of Engineering mechanics (2nd Edition): S Rajesekharan& G ShankaraSubramanium; Vikas Pub. House Pvt ltd.
2. Engineering mechanics: K. L. Kumar; Tata MC Graw Hill.

Course Outcomes:

- Draw free body diagrams and determine the resultant of forces and/or moments.
- Solve the problems involving dry friction.
- Determine the centroid and second moment of area of sections.
- Apply Newton's laws and conservation laws to elastic collisions and motion of rigid bodies.
- Determine the various parameters in projectile motion.

SESSIONALS

PHYSICS LABORATORY

1. Determination of 'g' by bar pendulum.
2. Verification of laws of transverse vibration of a string by using sonometer
3. Determination of surface tension of water by capillary rise method.
4. Thermal conductivity of a bad conductor by Lee's method
5. Determination of Youngs Modulus of wire by Searle's method.
6. Determination of Rigidity modulus of wire by static method.
7. Output characteristic of BJT
8. Determination of wavelength of monochromatic sources using Newton's ring
9. Determination of grating element of a plane diffraction grating using spectrometer
10. Determination of Planck's constant

BASIC ELECTRICAL ENGINEERING LABORATORY

List of Experiments

1. Preliminary: Preparation of symbol chart for various systems & components as per ISS, to study the constructional & operational features for Voltmeter, Ammeter, Wattmeter, Frequency meter, multi-meter and Rheostat, Study of safety rules as per ISS
2. Measurement of the armature & field resistance of D.C. Machine by volt-amp method. & Starting and speed control of a D.C. shunt motor
3. Study of BH Curve
4. Determination of open circuit characteristics (O.C.C) of D.C shunt generator when separately excited at different speeds.
5. Measurement of earth resistance and insulation resistance.
6. Starting of Induction motor and measurement of three phase power & power factor by 2-wattmeter method.
7. Callibration of a single phase Energy Meter by directed loading & Phantom loading.
8. Obtaining the voltage, current, power and power factor of fluorescent lamp.
9. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
10. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform

Course Outcomes

Upon completion of the subject the students will demonstrate the ability to:

CO1	Express the safety rules as per ISS and symbols of different electrical components and the use of various electrical instruments in laboratory.
CO2	Demonstrate the working and operational characteristics of dc motor and dc generator.
CO3	Evaluate the voltage, current, power and power factor of fluorescent lamp.
CO4	Implement the measurement of earth resistance and insulation resistance and demonstrate the internal structure of different machines.
CO5	Analyze the connection and calibration of single phase energy meter, three phase power and power factor by two wattmeter method and basic idea about converters.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**

CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	3	2	1	1	3	3	1	1

WORKSHOP AND MANUFACTURING PRACTICES:

1. Carpentry Section: Wooden rack/bench/chair/stool (any one)
2. Fitting Section: Paper Wt. Square or Rectangular joint (male and female joint) (any one)
3. Black Smith Section : Weeding hook/Hexagonal headed bolt blank (any one)

SECOND SEMESTER

THEORY

Mathematics-II (Differential Equations andComplex Variables)

Module 1: **Differential Equations*(8 Lectures)***

Exact ODEs, integrating factors, linear ODEs, Bernoulli equation, homogeneous linear odes of second order, homogeneous linear ODEs with constant coefficients, Euler-Cauchy equations,non- homogeneous ODEs, Applications Of ODEs to electric circuits

Module 2: **Power Series Solution of Differential Equations*(8 Lectures)***

Series solution of differential equation (excluding Frobenius method), Legendre'sequation, Legendre polynomials. Bessel's Equation, properties of Bessel's functions, Bessel Functions of the first and Second Kind.

Module 3: **Complex Variables *(8 Lectures)***

Complex valued function, differentiation, analytic function, Cauchy-Riemann equations, harmonic and conjugate harmonic functions, exponential function, trigonometric and hyperbolic functions, logarithm, generalpower

Module 4: **Complex Variables *(8 Lectures)***

Lineintegral in the complex plane,Cauchy's integral theorem, cauchy's integral formula, power series, radius of convergence, Taylor and Maclaurin series, singularities and zeros, Laurent series, Cauchy residue theorem(statement only) and applications.

Module 5: **Elementary Numerical Methods*(8 Lectures)***

Solution of algebraic and transcedental equations by Newton-Raphson and secant method.

Interpolation: Lagrange's method, divided difference method, Newton's forward and backward method. Numerical Integration: Trapezoidal and Simpson's Rule. Numerical solutions of differential equations: Euler's method and improved Euler'smethod.

Text Book:

Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd, 9th edition.

Reference Books:

1) K.A. Stroud, Advanced Engineering Mathematics, IndustrialPress
2) MiltonAbramowitz and Irene A. Stegun,*Handbook of Mathematical Functions*, National Bureau of Standards, Applied Mathematics Series -55
3) J. Sinha Roy and S. Padhy, Ordinary and Partial Differential Equation, KalyaniPublisher.
4) B.V. Ramana, Higher Engineering Mathematics, McGrawHill

COURSE OUTCOMES:

CO1: To gain adequate knowledge of the effective mathematical tools for the solutions of differential equations that models various physical processes.

CO2: To understand the basic knowledge ofpower series solution of differential equations.

CO3: To learn fundamental idea of analytic functions and applications of Cauchy-Riemann equations.

CO4: To apply the tools of integration of complex valued functions, and able to get Taylor and Laurent series expansions of functions that is useful in various fields of engineering problems.

CO5: To learn the techniques of extract of roots of algebraic and transcendental equations, and also able to evaluate the integrals by Trapezoidal and Simson's rules.

Chemistry

Course objective:

To awake the different fundamental concepts of chemistry that would help understanding the application of chemistry for engineering curricula.

Course Outcomes:

CO1: Apply the basic concept of classical mechanics and quantum chemistry to real life applications & to understand the basic concept of electromagnetic radiation, spectroscopic techniques and their applications.
CO2: Should perceive the spontaneity/feasibility of a process applying thermodynamics concepts and to keep up with the idea of phase equilibria, phase rule and its application to one and two component system.
CO3: Understand the application of electrochemistry to commercial electrochemical cell and corrosion.
CO4: Able to apply the basic concept of kinetics of a reaction to complex reactions.
CO5: Get to know the properties and applications of organometallics and nanomaterials.

Module–I **(9 Hours)**
Schrodinger Wave equations (not to be derived), Application to particle in ID box.

Molecular rotational (microwave) spectroscopy: Basic principle and application to diatomic molecules, selection rules.

M**olecular vibrational (IR) spectroscopy:** Basic principle, types of vibrations and vibrational frequency,application to Harmonic and anharmonic oscillators, selection rules, modes of vibration.

Electronic (UV-Visible) spectroscopy: Basis principle, types of electronic transitions, The Franck - Condon principle, and Jablonski diagram.

Module – II **(9 Hours)**

Thermodynamics of Chemical Processes:

Concept of Entropy and free energy, Chemical Potential, Equilibrium Conditions.

Phase equilibria:

Phase, Components, Degree of Freedom, Phase Rule Equation.

Phase Diagrams: One Component Systems – Water and Sulphur, Basic idea of (a) Peritectic system, (b) Eutectoid system, (c) Binary phase diagrams of Pb-Ag & Fe-C system.

Module–III **(9 Hours)**

Electrochemistry:

Electrode Potentials and its Relevance to Oxidation and Reduction, Types of electrodes, Galvanic cell, Measurement of EMF and application of EMF measurements, Types of reference electrodes (Hydrogen, Glass, Quinhydrone Electrodes,) Determination of pH, Electrochemical energy systems its types (Dry Cells, lead acid cell and Fuel Cells: Construction, reaction, advantages and applications).

Corrosion: Concept, types of corrosion, dry or chemical and wet or Galvanic/electrochemical Corrosion, Factors affecting corrosion.

Module–IV **(9 Hours)**

Kinetics of complex Chemical Reactions: Reversible, Consecutive and Parallel Reactions, Steady State Approximation, Chain reaction.

Module-V **(9 Hours)**

Chemistry of engineering materials:

Nanomaterials: Applications of nanomaterials.

Organometallics: Application of organometallics

Books Recommended:

1) P. W. Atkins, Elements of Physical Chemistry, 4th Edition, Oxford University Press

2) C. N. Banwell and E. M. MacCash, Fundamentals of Molecular Spectroscopy, 5th Edition,

3) P. K. Kar, S. Dash and B. Mishra, B.Tech. Chemistry Vol. I, Kalyani Publications

BASIC ELECTRONICS

COURSE OBJECTIVE:

1. To impart the fundamentals on electronic devices and its application to variouscircuits.
2. To impart the knowledge on Digital fundamentals and its application tocircuits.
3. To impart the knowledge on electronic measuring instruments and communicationfundamentals.

MODULE	CONTENT	HOURS
MODULE 1	Introduction to Electronics: - Signals, Frequency Spectrum of Signals, Analog and DigitalSignals, Linear Wave Shaping Circuits: - RC LPF, Integrator, RC HPF, Differentiator. Properties of Semiconductors: - Intrinsic, Extrinsic Semiconductors, Current Flow in Semiconductors, Diodes: - p-n junction theory, Current-Voltage characteristics, Analysis of Diode circuits, Rectifiers, Clippers, Clampers, Special diodes- LED, Photo diode, Zener Diode.	**(12 Hours)**
MODULE 2	Bipolar junction Transistor (BJTs):- Device Structure and Operation, Current-Voltage Characteristics, BJT as an Amplifier and as a Switch. Introduction to Power Amplifiers: - A,B and Ctypes. JFET:- Physical Structure, Operation and Characteristics	**(10 Hours)**
MODULE 3	Feedback Amplifiers: - General Feedback Structure, Properties of Negative Feedback, Four Basic Feedback Topologies (block diagram only), Practical feedback circuit. Operational Amplifiers (OP-AMPs): - The Ideal OP-AMP, Inverting Configuration, Non-Inverting Configuration. OP-AMP Applications (Adder, Subtractor, Integrator, Differentiator).	**(08 Hours)**
MODULE 4	Digital Fundamentals:- Binary Numbers, Signed-binary numbers, Decimal-to-Binary & Binary-to-Decimal Conversion, Binary Addition, Subtraction, Multiplication and Division, Hexadecimal Number Systems, Logic Gates, Boolean Algebra, De Morgan’s Theorems, Laws of Boolean Algebra, RS Flip Flop	**(06 Hours)**

MODULE 5	Introduction to Electronic Instruments: - CRO: CRT, Waveform Display, Applications of CRO, Electronic Multimeter, Audio Signal Generator: - Block diagram, Front Panel Controls. Principles of Communication:- Fundamentals of AM & FM, Block diagram of Transmitters	**(06 Hours)**
TEXT BOOK	**1.** Microelectronics Circuits, A.S Sedra, K.C. Smith, Oxford UniversityPress. Selected portions from chapters 1 to 3, 5, 8,13. **2.** Electronics Fundamentals and Applications, D Chattopadhyay and P.C. Rakshit, New Age International Publications. Selected portions fromchapters 4 to 12, 14, 16 to 18,20,21.	
REFERENCE BOOK	1. Integrated Electronics, Millman and Halkias, TMHPublications. 2. Electronic Devices & Circuit Theory, R.L Boylestad and L.Nashelsky, PearsonEducation.	

COURSE OUTCOME: After completion of course student should be able to

1. Understand different types of signals and its application to semiconductor devices andcircuits.
2. Understand different BJTs and itsoperation.
3. Understand the Feedback Amplifiers and Operational Amplifiers.
4. Understand fundamentals of different Digital arithmetic operations and Digitalcircuits.
5. Understand some important Electronic Instruments and Communicationsystems.

PROGRAMMING FOR PROBLEM SOLVING

Course Objective:

1. The objective of the course is to illustrate flowchart and algorithm for a given problem,
2. Understand basic Structure of the C-PROGRAMMING,
3. Declaration and usage of variables, inscribe C programs using operators, exercise conditional and iterative statements to inscribe C programs,
4. Solve real time problems using functions and inscribe C programs using Pointers to access arrays, strings and functions.

Module I: (8 Lectures)

Introduction to computing- Block architecture of a computer, fundamental units of storage: bit, bytes, nibbles, word size. Introduction to problem solving- Basic concepts of an algorithm, program design methods, flowcharts. Level of programming Languages, structure of C program, Compiling and Executing C program

Module II: (8 Lectures)

C Language Fundamentals- Character set, Identifiers, Keywords, Data Types, Constant and Variables, Statements. Input &Output - Input & Output Assignments, Formatted Outputs. Operators and Expressions-Operators, Precedence of operators. Decision Control Structure, Loop Control Structure and Case Control Structure.

Module III: (8 Lectures)

Functions: Monolithic vs Modular programs, User defined vs standard functions, formal vs Actual arguments, Functions category, function prototypes, parameter passing, Recursion.Arrays1D Array, 2D Array & Multi-Dimensional Array. Strings- Declaration & Initialization, String Handling Functions.

Module IV: (8 Lectures)

Pointer variable and its importance, Pointer Arithmetic, Passing parameters, pointer to pointer, pointer to function. Dynamic Memory Allocation. Structure, Nested Structure, Array of Structures, Pointer to Structure, Structure & Functions, Union, Array of Union Variables, Union inside Structure, Bit Fields. Storage Class.

Module V: (8 Lectures)

Preprocessor Directives- Types, Pragma Directives, Conditional Directives. typedef, Enumerated Data Type. Files- Reading data from Files, Reading data from Files, Writing data to Files, Error Handling during File Operations. Advanced Issues in Input & Output – using argc&argv.

Text Books:

1. Programming in ANSI C, E Balaguruswamy

2. Computer Fundamentals &Programming in C: ReemaThareja, Oxford University Press.

Reference Books:

1. Let us C- Y.Kanetkar, BPB Publications.
2. Programming with ANSI and Turbo C- Kamthane, A.N. Pearson Education
3. C How to Program- Deitel and Deitel, Pearson Education.
4. The C Programming Language- Brian W. Kernighan and Dennis M. Ritchie, PrenticeHall.

Course Outcomes:

1. Students will learn the fundamentals of Computer and problem solving.
2. Students will learn the fundamentals of C Programming along with control structures.
3. Implementation of different problems on functions and arrays.
4. Application of pointers structures and unions for problem solving.
5. Gain knowledge of pre-processor directives and file operations.

Basic of Civil Engineering

Introduction to Civil Engineering – Various disciplines of Civil engineering, Importance of Civil engineering in infrastructure development of the country.

Introduction to types of buildings as per NBC, Selection of site for buildings, Components of a residential building and their functions, Introduction to Industrial buildings and types.

Building Planning – Basic requirements, elements, introduction to various building area terms, computation of plinth area, carpet area.

Module-II

Surveying – Principle and objectives, Instruments used, Horizontal measurements, Ranging (direct ranging only), Instruments used for ranging, Leveling – Definition, Principles, Instruments, Preparation of level book, problems on leveling, Modern surveying instruments – EDM, Total station, GPS (Brief discussion)

Building Materials – Bricks, properties and specifications, Cement – Types, properties, grades, other types of cement and uses, Cement mortar – Constituents, Preparation, Concrete – PCC and RCC, Grades, Steel – Use of steel in buildings, types.

Module-III

Building Construction – Foundations, Classification, Bearing Capacity of Soil and related terms (definition only), Masonry Works – classifications, definition of different technical terms, Brick masonry – types, bonds, general principle, Roofs – functional requirements, basic technical terms, roof covering material, Floors – function, types, flooring materials(brief discussion), Plastering and Painting – objectives, types, preparation and procedure of application.

Module-IV

Basic Infrastructure services – air conditioning & purpose, fire protection & materials, Ventilation, necessity & functional requirements, Lifts, Escalators.

Introduction to planning and design aspects of transportation engineering, Transportation modes, Highway engineering – historical development, highway planning, classification of highway, Railway Engineering – cross section of rail track, basic terminology, geometric design parameter(brief discussion only).

Module-V

Airport engineering – development, types, definition, characteristics of aircraft, basic terminology, Traffic engineering – traffic characteristics, traffic studies, traffic operations (signals, signs, markings), Urban engineering – classification of urban road.

Irrigation & Water Supply Engineering – Introduction, Types of Irrigation, different types of hydraulic structures, dam and weirs, types of dam, purpose and functions.

Text Books:

- Basic Civil engineering, Gopi, S., Pearson Publication
- Basic Civil Engineering, Bhavikatti, S. S., New Age.

Reference Books:

- Construction Technology, Chudley, R., Longman Group, England
- Basic Civil and Environmental Engineering, C.P. Kausik, New Age.
- American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application

Course Outcomes:

1. Create fundamental aspect of building planning.
2. Express general aspect of building material and surveying.
3. Develop building constructions.
4. Apply transportation modes and planning.
5. Demonstrate Airport & Irrigation Structures.

Sessional

Chemistry Laboratory

Course Objectives:

To provide hands-on opportunities to develop fundamental laboratory analytical skills and apply this knowledge in executing project work and solving basic industrial problems in future

Course Outcomes:

- Develop knowledge of concepts and applications of chemistry, important laboratory analytical techniques, and instrumentation.
- Understand fundamental principles for environmental analytical methods.
- Identify suitable analytical techniques for analyzing a specific compound in a sample.
- Understand suitable techniques for sampling and handling of environmental and chemical samples.
- Know quality control on chemical analysis and laboratory work and its importance
- Hands on training on using different laboratory apparatus and equipments including data analysis and conclusions.

List of Experiments to be done (Any ten Experiments)

1. Determination of amount of sodium hydroxide and sodium carbonate in a Mixture.
2. Determination of Total hardness of water by EDTA method.
3. Estimation of calcium present in the limestone.
4. Standardization of $KMnO_4$ using sodium oxalate.
5. Determination of ferrous iron in Mohr's salt by potassium permanganate.
6. Determination of Rate constant of acid catalyzed hydrolysis of ester.
7. Determination of dissolved oxygen in a sample of water.
8. Conductometric titration of strong acid and strong base
9. Determination of Viscosity of lubricating oil by red wood Viscometer.
10. Determination of Flash point of given oil by Pensky Marten's Flash Point Apparatus.
11. Determination of available chlorine in bleaching powder.
12. Preparation of acidic and basic buffer solution and measurement of P^H using P^H meter

Book Recommended:

B. Tech Practical Chemistry-Kalyani Publisher.

BASIC ELECTRONICS LAB

SESSIONAL OBJECTIVE:

1. To provide engineering skills for circuit design on breadboard with electroniccomponents.

2. To impart the knowledge on digital fundamentals and digital circuitdesign.

3. To analyze various Electronic circuits such as BJT, FET, OP-AMPs, Logic gatesetc.

Experiment No.	CONTENT
1	Familiarity with electronic components and devices(Testing of semiconductor diode, Transistor, IC Pins connection) Digital Multimeter should be used.
2	Study and use of CRO to view waveforms and measure its Amplitude and Frequency.
3	Frequency response of LPF and HPF.
4	V-I Characteristics of a Semiconductor Diode. Determining DC and AC resistance.
5	Clipper Circuit.
6	Clamper Circuit.
7	Half Wave and Full Wave Rectifier without Capacitor filter. Record of Waveforms, Measurement of Average and RMS value.
8	V-I (Output) Characteristics of N-P-N/P-N-P Transistor in CE Configuration.
9	OP-AMP: Inverting and Non-Inverting Configuration. Record of Waveforms.
10	Verification of Truth table of Logic gates (AND, OR,NOT, NAND, NOR, EX-OR)
SUPPLEMENTARY BOOK	1. Integrated Electronics, Millman and Halkias, TMHPublications. 2. Electronic Devices & Circuit Theory, R.L Boylestad andL. Nashelsky, PearsonEducation.

SESSIONAL OUTCOME: After completion of the sessional student should be able to

1. Acquire basic knowledge on electronic devices andcomponents
2. Design different electronics circuits using semiconductordiodes.
3. Analyze and develop the characteristics of BJT and FETCircuits
4. Implement Operational amplifiercircuits.
5. Acquire knowledge on basic digital logicgates.

PROGRAMMING FOR PROBLEM SOLVING LAB

1. WAP to display student's data.
2. Input the roll no., name & marks in 4 subjects of a student. Calculate and print the total and average respectively.
3. WAP to Find LCM of two Numbers
4. WAP using do- while loop to display the square & cube of 1st n natural nos.
5. WAP to display prime numbers between Two Intervals
6. WAP to print Pascal's triangle
7. WAP of Simple Calculator using switch Statement
8. WAP to convert binary number to decimal
9. WAPto calculate the power using recursion
10. WAP to add two matrix using multi-dimensional arrays
11. WAP to Find the Frequency of Characters in a String
12. WAP to reverse an array using pointers
13. WAP to store information using structures with dynamically memory allocation

14. WAP to create a sequential file Inventory.dat storing the inventory data. The file contains the name of the product, nos, price & quantity for 10 items. WAP to read the records created & print the records along with the value of each item.

Engineering Graphics & Design

Course Content

Module-I

Introduction to Engineering Drawing: Drawing instruments, lines, lettering and dimensioning.

Scales: Plain, Diagonal and Vernier Scales.

Module-II

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute.

Module-III

Orthographic Projections: Concepts, Orthographic projections of points, Lines, Planes and Solids. Sections of solids; Development of surfaces

Module-IV

Isometric Projections: Principles, Isometric Scale, Isometric Views, Isometric Views of lines, Planes, Simpleand compound Solids.

Module-V

Introduction to Auto-Cad:

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute

Reference Books:

1 Engineering drawing by N.D. Bhatt and V.M Panchal, Charotar Publishing House, Anand.

Engineering Drawing by Venugopal, New Age publisher.

Course Outcomes:

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

1. Understand basics of engineering drawings and curves.
2. Understand Orthographic projections of Lines, Planes, and Solids.
3. Sectioning of various Solids and their representation.
4. Conversion of Pictorial views to Orthographic Projections
5. Construction of Isometric Scale, Isometric Projections and Views.

Third Semester

Mathematics-III

(Transforms, Probability and Statistics and Multivariate Analysis)

Module 1:**Laplace Transforms *(10 Lectures)***

Laplace transforms, inverse transforms, linearity, shifting, transforms of derivatives and integrals, solution of ODEs, unit step function, Dirac's delta function, differentiation and integration of transforms, convolution, integral equations.

Module 2:* Fourier Transforms *(8 Lectures)

Basic concept of Fourier integral, Fourier sine and cosine integral, condition of convergence, Fourier transformation, Fourier sine transform, Fourier cosine transform, properties.

Module 3:**Probability*(6 Lectures)***

Random variables, probability distributions, mean and variance, Binomial, Poisson and hyper-geometric distributions, Normal distribution.

Module 4:* Statistics*(8 Lectures)

Random sampling, point estimation of parameters, maximum likelihood estimation, confidence intervals, testing of hypotheses for mean and variance, correlation and regression.

Module 5:* Multi-variate Analysis*(8 Lectures)

Line integrals, double integrals, change of order, Green's theorem(statements only), surface integrals, triple integrals, Divergence theorem of Gauss(statements only), Stoke's theorem(statements only) and applications.

Text Book:

Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd, 9th edition

Reference Books:

1) B.V. Ramana, Higher Engineering Mathematics, McGrawHill
2) K.A. Stroud, Advanced Engineering Mathematics, IndustrialPress

COURSE OUTCOMES:

CO1:To acquire basic knowledge of Laplace and Fourier transforms, and able to solve differential equations by using Laplace transforms.

CO2: To develop knowledge of different methods of proofs for learning advanced Engineering Mathematics.

CO3:To apply Binomial, Poisson and Normal distributions in probabilistic models.

CO4: To get adequate knowledge of random sampling and estimation of parameters.

CO5: To experience the mathematical tools useful in evaluating multiple integrals and applications.

ELECTRICAL MACHINES-I

SYLLABUS

Module-I (10 hours)
Transformers: Review of magnetic circuits. Single phase transformer: Constructional details, Core, windings, Insulation, principle of operation, emf equation, magnetizing current and core losses, no load and on load operation, Phasor diagram, equivalent circuit, losses and efficiency, condition for maximum efficiency, voltage regulation, approximate expression for voltage regulation, open circuit and short circuit tests, Sumpner'stest.Autotransformers.

Module-II (8 hours)
Electromechanical Energy conversion: Forces and torque in magnetic field systems – energy balance, energy and force in a singly excited magnetic field system, determination of magnetic force, energy; multi-excited magnetic field systems.
Basic concepts of DC Machines: Principle of operation, Action of commutator, constructional features, armature windings, lap and wave windings, simplex and multiplex windings, use of laminated armature, E.M.F. Equation,Armature reaction: Cross magnetizing and demagnetizing AT/pole, compensating winding, commutation, reactance voltage, methods of improving commutation.

Module-III (4 hours)
DC Generators –Methods of Excitation: separately excited and self excited generators, build up of E.M.F., critical field resistance and critical speed, causes for failure to self excite and remedial measures, Load characteristics of shunt, series and compound generators, parallel operation of DC generators, use of equalizer bar and cross connection of field windings, load sharing.

Module-IV (10 hours)
DC Motors: Principle of operation, Back E.M.F., Torque equation, characteristics and application of shunt, series and compound motors, Armature reaction and commutation, Starting of DC motor, Principle of operation of 3 point and 4 point starters, drum controller, Constant & Variable losses, calculation of efficiency, condition for maximum efficiency.

Speed control of DC Motors: Armature voltage and field flux control methods, Ward Leonard method.
Methods of Testing: direct, indirect and regenerative testing, brake test, Swinburne's test, Load test, Hopkinson's test, Field's test, Retardation test, separation of stray losses in a DC motor test.

Module-V (7 hours)
Three phase Transformers: Constructional features of three phase transformers – three phase connection of transformers (Dd0, Dd6, Yy0, Yy6, Dy1, Dy11, Yd1, Yd11, zigzag), Scott connection, open delta connection, three phase to six phase connection, oscillating neutral, tertiary winding, three winding transformer, equal and unequal turns ratio, parallel operation, load sharing.Inrush of switching currents, harmonics in single phase transformers, magnetizing current wave form.

Text Books:
[1]. J. Nagrath, D. P. Kothari, "Electric Machines", TMH Publishers.
[2]. A. E. Clayton, N. Hancock, "Performance and Design of D.C Machines", BPB Publishers

Reference Books:
[1]. A. E. Fritzgerald, C. Kingsley, and S. Umans, "Electric Machinery", TMH Publisher.
[2]. P.S. Bhimra, Electrical Machinery (Part 1, Part 2), Khanna Publishers.

Course Outcomes:
Upon completion of the course, the students will demonstrate the ability to:

CO1	Describe and analyze the performance of single phase transformers.
CO2	Apply knowledge on the basic concepts of electromagnetic energy conversion and dc machines.
CO3	Express and analyze the performance of DC generators.
CO4	Describe and analyze the performance of DC motors.
CO5	Define and analyze the performance of three phase transformers.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

NETWORK THEORY

MODULE-I (9 HOURS)

Analysis of Coupled Circuits: Self-inductance and Mutual inductance, Coefficient of coupling, Series connection of coupled circuits, Dot convention, Ideal Transformer, Analysis of multi-winding coupled circuits, Analysis of single tuned and double tuned coupled circuits.

Transient Response: Transient study in series RL, RC, and RLC networks by time domain and Laplace transform method with DC and AC excitation. Response to step, impulse and ramp inputs of series RL, RC and RLC circuit.

MODULE-II (7 HOURS)

Two Port networks: Types of port Network, short circuit admittance parameter, open circuit impedance parameters, Transmission parameters, Condition of Reciprocity and Symmetry in two port network, Inter-relationship between parameters, Input and Output Impedances in terms of two port parameters, Image impedances in terms of ABCD parameters, Ideal two port devices, ideal transformer. Tee and Pie circuit representation, Cascade and Parallel Connections.

MODULE-III (8 HOURS)

Network Functions & Responses: Concept of complex frequency, driving point and transfer functions for one port and two port network, poles & zeros of network functions, Restriction on Pole and Zero locations of network function, Time domain behavior and stability from pole-zero plot, Time domain response from pole zero plot.

Three Phase Circuits: Analysis of unbalanced loads, Neutral shift, Symmetrical components, Analysis of unbalanced system, power in terms of symmetrical components.

MODULE-IV (9 HOURS)

Network Synthesis: Realizability concept, Hurwitz property, positive realness, properties of positive real functions, Synthesis of R-L, R-C and L-C driving point functions, Foster and Cauer forms.

MODULE-V (6 HOURS)

Graph theory: Introduction, Linear graph of a network, Tie-set and cut-set schedule, incidence matrix, Analysis of resistive network using cut-set and tie-set, Dual of a network.

Filters: Classification of filters, Characteristics of ideal filters.

TEXT BOOKS

[1]. A. Chakrabarti, “Circuit Theory (Analysis and Synthesis)”, Dhanpat Rai Publications.
[2]. Mac.E Van Valkenburg, “Network Analysis”, PHI Learning publishers.
[3]. Franklin Fa-Kun. Kuo, “Network Analysis & Synthesis”, John Wiley & Sons.

REFERENCE BOOKS

[1]. M. L. Soni, J. C. Gupta, “A Course in Electrical Circuits and Analysis”, Dhanpat Rai Publications.
[2]. Mac.E Van Valkenburg, “Network Synthesis”, PHI Learning publishers.
[3]. Joseph A. Edminister, Mahmood Maqvi, “Theory and Problems of Electric Circuits”, Schaum's Outline Series, TMH publishers.

Course Outcomes:

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

CO1	Analyze coupled circuits and understand the difference between the steady state and transient response of 1st and 2nd order circuit and understand the concept of time constant.
CO2	Define the different parameters of two port network.
CO3	Concept of network function and three phases circuit and know the difference of balanced and unbalanced system and importance of complex power and its components.
CO4	Synthesis the electrical network.
CO5	Analyze the network using graph theory and understand the importance of filters in electrical system.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

INSTRUMENTATION AND SENSORS

Syllabus:

Module-I (8 Hours)

Measuring Instruments: Classification, Absolute and secondary instruments, indicating instruments, deflecting, control and damping torques, Ammeters and Voltmeters, PMMC, Moving Iron (MI) type, expression for the deflecting torque and control torque, extension of range using shunts and series resistance. Electrostatic Voltmeters-electrometer type and attracted disc type, extension of range of E.S. Voltmeters.

Module-II (8 Hours)

Electrodynamometer type wattmeter – Theory & its errors – Methods of correction – LPF wattmeter – Phantom loading – Induction type KWH meter – Calibration of wattmeter, energy meter. Measurement of active and reactive powers in balanced and unbalanced systems.
Galvanometers: General principle and performance equations of D'Arsonval Galvanometers, Vibration Galvanometer and Ballistic Galvanometer.

Module-III (8 Hours)

DC/AC Bridges: General equations for bridge balance, measurement of self-inductance by Maxwell's bridge (with variable inductance & variable capacitance), Hay's bridge, Owen's bridge, measurement of capacitance by Schearing bridge, errors, Wagner's earthing device.
Method of measuring low, medium and high resistance: Kelvin's double bridge for measuring low resistance, Wheat-stone's bridge, measurement of high resistance – loss of charge method.

Module-IV (8 Hours)

Instrument Transformers: Potential and current transformers, ratio and phase angle errors, phasor diagram, methods of minimizing errors.
Potentiometers: DC Potentiometer, Crompton potentiometer, construction, standardization, application. AC Potentiometer, Drysdale polar potentiometer; standardization, application.

Module-V (7 Hours)

Digital Multi-meter: Block diagram, principle of operation, Accuracy of measurement, Electronic Voltmeter: Transistor Voltmeter, Block diagram, principle of operation, various types of electronic voltmeter, Digital Frequency meter: Block diagram, principle of operation
Definition of transducers, Classification of transducers, Advantages of Electrical transducers, Characteristics and choice of transducers; Principle operation of LVDT and capacitor transducers; LVDT Applications, Strain gauge and its principle of operation, gauge factor.

TEXT Books

[1]. A K. Sawhney, “A Course in Electrical & Electronics Measurements & Instrumentation”, Dhanpat Rai Publications.

[2]. Helfrick& Cooper, “Modern Electronic Instrumentation and Measurement Techniques”,PHIPublshers.

REFERENCE BOOKS

[3]. Larry Jones &A Foster Chin, “Electronic Measurement & Instrumentation Systems”, John Wiley & Son Publishers.

[4]. Golding &Waddis, “Electrical Measurement and Measuring Instruments”,Reem Publishers.

Course Outcomes:

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

CO1	Describe the principles of basic electrical measuring instruments.
CO2	Define and apply knowledge on the operation of wattmeter, energy meter and galvanometers.
CO3	Define and analyze the working of different ac and dc bridges
CO4	Describe the operation of instrument transformers and potentiometers
CO5	Describe the operation of electronic measuring instruments and transducers

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

ORGANIZATIONAL BEHAVIOUR

Objectives:

1. To develop an understanding of the behavior of individuals and groups inside organizations

2. To enhance skills in understanding and appreciating individuals, interpersonal, and group process for increased effectiveness both within and outside of organizations.

3. To develop theoretical and practical insights and problem-solving capabilities for effectively managing the organizational processes.

Unit Contents Class Hours

Unit 01 Fundamentals of OB: Definition, scope and importance of OB, Relationship between OB and the individual, Evolution of OB, Theoretical framework (cognitive), behavioristic and social cognitive), Limitations of OB.

Unit 02 Attitude: Importance of attitude in an organization, Right Attitude, Components of attitude, Relationship between behavior and attitude, Developing Emotional intelligence at the workplace, Job attitude, Barriers to changing attitudes.

Personality and values: Definition and importance of Personality for performance, The Myers-Briggs Type Indicator and The Big Five personality model, Significant personality traits suitable to the workplace (personality and job – fit theory), Personality Tests and their practical applications.

Perception: Meaning and concept of perception, Factors influencing perception, Selective perception, Attribution theory, Perceptual process, Social perception (stereotyping and halo effect).

Motivation: Definition & Concept of Motive & Motivation, The Content Theories of Motivation (Maslow's Need Hierarchy, Aldefer ERG theory& Herzberg's Two Factor model Theory).

Unit 03 Foundations of Group Behavior: The Meaning of Group & Group behavior & Group Dynamics, Types of Groups, The Five – Stage Model of Group Development. Managing Teams: Why Work Teams, Work Teams in Organization, Developing Work Teams, Team Effectiveness & Team Building. Leadership: Concept of Leadership, Styles of Leadership, Trait Approach Contingency Leadership Approach, Contemporary leadership, Meaning and significance of contemporary leadership, Concept of transformations leadership, Contemporary theories of leadership, Success stories of today's Global and Indian leaders.

Unit 04 Organizational Culture : Meaning & Definition of Organizational Culture, creating & Sustaining Organizational Culture, Types of Culture (Strong vs. Weak Culture, Soft Vs.

Hard Culture & Formal vs. Informal Culture), Creating Positive Organizational Culture, Concept of Workplace Spirituality.

Unit 05 Organizational Change: Meaning, Definition & Nature of Organizational Change, Types of Organizational Change, Forces that acts as stimulants to change. Implementing Organizational Change : How to overcome the Resistance to Change, Approaches to managing Organizational Change, Kurt Lewin's-Three step model, Seven Stage model of Change &Kotter's Eight-Step plan for Implementing Change, Leading the Change Process, Facilitating Change, Dealing with Individual & Group Resistance, Intervention Strategies for Facilitating Organizational Change, Methods of Implementing Organizational Change, Developing a Learning Organization.

Reference Books

1. Understanding Organizational Behaviour, Parek, Oxford

2. Organizational Behaviour, Robbins, Judge, Sanghi, Pearson.

3. Organizational Behaviour, K. Awathappa,HPH.

4. Organizational Behaviour, VSP Rao, Excel

5. Introduction to Organizational Behaviour, Moorhead, Griffin, Cengage.

6. Organizational Behaviour, Hitt, Miller, Colella, Wiley

Sessionals

NETWORK THEORY LABORATORY

Course Objectives:-

- *To gain knowledge for solving linear circuits using network theorems.*
- *To understand resonant circuit by understanding its basic properties and find the bandwidth, Q-factor and resonance frequency of a R-L-C series circuit.*
- *To get knowledge on the Transient response of R-L, R-C and R-L-C circuits using DC excitation.*
- *To comprehend ABCD, Z, Y and h parameters of a two port network and know the property of symmetry and reciprocity of network.*
- *To analyze the spectral analysis of non-sinusoidal waveform.*

List of Experiments:

1. Verification of Superposition and Thevenin's Theorem.
2. Verification of Maximum Power Transfer Theorem.
3. Find out the band width, Q-factor and resonance frequency of a R-L-C series circuit.
4. Transient response of a D.C. R-L, R-C and R-L-C circuit.

5. Determination of ABCD, Z,Y and h parameters of a two port network.
6. Spectral Analysis of a non-sinusoidal waveform.

Course Outcomes:

Upon successful completion of this course, students should be able to

CO1	Implement the linear circuits by using network theorems.
CO2	Describe the resonant circuit by understanding its basic properties and find the bandwidth, Q-factor and resonance frequency of a R-L-C series circuit.
CO3	Describe and evaluate the Transient response of R-L, R-C and R-L-C circuits using DC excitation.
CO4	Define ABCD, Z, Y and h parameters of a two port network and know the property of symmetry and reciprocity of network.
CO5	Define and analyze the importance and reason that lead to a non-sinusoidal waveform.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

ELECTRICAL CIRCUIT COMPUTATION LABORATORY

List of Experiments:

1. Power measurement of AC system using MATLAB:
2. Time response of a first/ second order system using Laplace Transform.
3. Numerical analysis: Non-linear equations and optimization, Differential equations
4. Series & parallel resonance circuit simulation.
5. Simulation of Half wave diode bridge rectifier circuit.
6. Simulation of Full wave diode bridge rectifier circuit.
7. DC analysis for R-L, R-C and R-L-C circuits using MATLAB.
8. AC analysis for R-L, R-C and R-L-C circuits using MATLAB.

Course Outcomes:

After completion of this laboratory course the students will be able to

CO1	Describe the MATLAB software and its application in DC, single phase and three phase electric circuit to analyze.
CO2	Recognize for solving other electrical problems using the software.
CO3	The students can interpret and summarize from the response the type of the system.
CO4	Discover how to apply the different numerical techniques for analysis of electrical systems and its implementation with MATLAB.
CO5	Design circuit simulation in different ways by both programming and Simulink blocks in MATLAB.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

ELECTRICAL MACHINES-I LABORATORY

LIST OF EXPERIMENTS

1. Open circuit and short circuit on single phase transformer
2. Parallel operation of two single phase transformer and load sharing
3. Back –to-back test of Single phase transformer
4. Load characteristics of DC shunt/compound generator
5. Load characteristics of DC series Motor
6. Swinburne test and brake test of DC shunt machine

Course Outcomes:

Upon successful completion of this course, students should be able to:

CO1	Perform parallel connection of single phase transformers
CO2	Evaluate performance of DC series and shunt motors.

CO3	Compute the efficiency of transformer by different experimental tests.
CO4	Perform tests to evaluate performance of DC machine and transformers.
CO5	Estimate load performance of DC series motor

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	3	2	1	1	3	3	1	1

INSTRUMENTATION LABORATORY

List of Experiments

1. Study the role of various sensors and actuators in measuring physical / electrical parameters or variables and able to distinguish between conventional and smart sensors.
2. Study of a linear system simulator and learn about linear approximations of a non-linear functions or a system.
3. Measurement of unknown resistance, inductance and capacitance using bridges and its realizations using breadboard or using NI cRIO platforms.
4. To plot the displacement- voltage characteristics of the LVDT.
5. Study and plot the characteristics of different temperature sensors/ transducers namely RTD, Thermistor and Thermocouples and its calibration with soft temperature sensors using LM 34/35 or AD 220.

Course Outcomes:

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

CO1	Express the basic principles and design requirements of smart / modern measurement schemes.
CO2	Design necessary signal conditioning circuits for the measurement of resistance, inductance and capacitance.
CO3	Define the principles of operations of displacement measurement using inductive method.
CO4	Describe the linear system simulation and linear approximation.
CO5	Describe the principles of operations of temperature sensors.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

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

Course	3	3	2	1	3	2	1	1	3	3	1	1

Fourth Semester

ELECTRICAL MACHINES-II

Syllabus

Module-I (8 hours)
Three phase synchronous generators: Principle and construction, relation between speed & frequency, three-phase windings, winding factors, EMF equation, Harmonic EMFs.
Cylindrical rotor theory: armature reaction, armature reaction reactance, synchronous reactance, phasor diagram, open & short circuit characteristics, short-circuit ratio, load characteristics.

Module-II (8 hours)
Voltage regulation, EMF method, MMF method, modified MMF method, ZPF method, Theory of salient pole machine: Blondel's two reaction theory, phasor diagram, direct and quadrature axis synchronous reactances, Slip Test. Power Angle characteristics. Synchronizing coefficient.

Module-III (8 hours)
Parallel operation: Synchronizing method, effect of wrong synchronization, load sharing between alternators in parallel. Sudden Short Circuit of a Synchronous Generator, Transient and Sub-transient reactances.
Synchronous Motors: Operating principle, torque-angle characteristics in non-salient pole and salient pole motors, Effect of change of excitation, V-curves & inverted V-curves, power factor correction applications. Hunting.

Module-IV (8 hours)
Three Phase Induction Motors: Types, Construction and principle of operation. Torque-slip characteristics, condition for maximum torque, effect of rotor resistance, stable & unstable region of operation. Losses and efficiency. Equivalent circuit, phasor diagram, circle diagram and performance equations. Operation with unbalanced supply voltage. Methods of starting (DOL, stator resistance starter, autotransformer starter, star-delta starter, rotor resistance starter). Methods of speed control. Double cage induction motor, Cogging and Crawling of Induction motor.

Module-V (7 hours)
Induction Generator: types, principles and applications.
Single phase induction motor: theory of operation (Double revolving field theory, equivalent circuit, Determination of parameters). Methods of starting: split phase starting, Repulsion starting, shaded pole starting, performance characteristics.
Single phase series motor, theory of operation performance and application. Universal motor.

Text Books:

[1]. J. Nagrath, D. P. Kothari, "Electric Machines", TMH Publishers.
[2]. M. G. Say, "Performance and design of AC machines", CBS Publishers.

Reference Books:

[1]. A. E. Fritzgerald, C. Kingsley, and S. Umans, "Electric Machinery", TMH Publisher.
[2]. P.S. Bhimra, Electrical Machinery (Part 1, Part 2), Khanna Publishers.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Describe fundamental principles and classification of synchronous machines.
CO2	Evaluate voltage regulation and analyze power angle equation.
CO3	Analyze and evaluate the performance characteristics of synchronous motors.
CO4	Describe and evaluate the performance of three phase induction motors.
CO5	Analyze and evaluate the performance of single phase motors.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

ELECTRIC POWER GENERATION SYSTEMS

Syllabus

Module-I (8 hours)

Introduction: Sources of energy, general discussion on their application to generation and current share in India and World, concept of sustainable energy.

Hydro Power: Hydrology: catchment area, hydrograph, flow duration curve, estimation of power potential. Classification of hydro power plants. Hydro plant components: dams, spillway, head race, surge tank, penstock, scroll casing, draft tube and tail race. Hydraulic Turbines: specific speed, operational principle of Kaplan, Francis and Pelton turbines.

Module-II (8 hours)

Thermal Power: Coal resource: relationship between MW capacity and fuel consumption. Overall plant components in block diagrams indicating air circuit, coal and ash circuit, water and steam circuit, cooling water circuit. Coal and ash handling systems; boilers, superheater, reheater, economizer, air preheater, dust collection, draught fans and chimney; condensers and cooling towers, feed water heaters, makeup water treatment. Steam turbines.

Module-III (7 hours)

Nuclear Power: Relationship between MW capacity and fuel consumption. Reactor classification. Reactor schematic and components. Boiling water reactors, pressurized water reactors, fast breeder reactors. Heavy water reactors. Fusion Power Reactors. Waste management.

Introduction to renewable power: Characteristics of wind and solar resource; Overview of components and working of wind farm and photovoltaic solar power plants.

Module-IV (8 hours)

Electrical Systems: Types of alternators (hydro, thermal, wind).Cooling and ventilation-insulation and temperature limits; fire protection. Excitation systems: DC, AC and Static. Automatic Voltage Regulators. Mechanical governors, electro hydraulic governors, digital governors, pressurized oil system. Power plant auxiliaries. Planning and layout of electrical equipment. Power station transformers. Commissioning tests. Switchyard components. Power electronic interfaces of wind and solar PV plants. Power evacuation systems. Power quality.

Module-V (8 hours)

Economics of Power Generation: Load curve, load duration curve. Maximum demand, load factor, diversity factor, plant capacity and use factor. Choice of size and number of generating units, Types of reserves. Social, economic, environmental and technological sustainability.

Life Cycle Cost, Levelized cost of generation, opportunity cost, shadow pricing. Generator Cost Curves, Energy pricing and tariff principles. Power Exchanges, Spot Pricing. National Grid. Introduction to concepts of Smart Grid.

Text Books:
Generation of Electrical Energy by B. R. Gupta, S.C. Chand Publishers

Reference Books:
Power Plant Engineering by P. K. Nag

Course Outcomes:
Upon completion of the course, the students will demonstrate the ability to:

CO1	Describe the components and working of hydro power plants.
CO2	Describe the components and working of thermal power plants.
CO3	Describe the components and working of nuclear, wind and solar power plants.
CO4	Recognize electrical components in power generating stations.
CO5	Apply knowledge on power generation planning and economics.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

ANALOG AND DIGITAL ELECTRONIC CIRCUITS

MODULE-I (9 Hours)
Biasing of BJT: Fixed bias circuit, Self-bias circuit, Feedback bias circuit, Bias Stabilization. Transistor at Low Frequencies: Transistor Hybrid Model, h- parameters, Analysis of the transistor amplifier using h-parameter. Emitter Follower, Miller’s theorem and its dual, cascading transistor amplifiers, Simplified CE and CC configurations. Transistor at high frequency: Hybrid-pi CE Transistor Model.

MODULE-II (6 Hours)

Biasing the JFET: FET in fixed bias, self-bias and feedback bias configurations. FET small signal modelling. Frequency response of an amplifier, Bode plot, Bandpass of cascaded stages, RC-Coupled amplifier and its low frequency response. Classification of amplifier, Feedback concept, Transfer gain, Negative feedback, Input-output resistance, Method of analysis of a feedback amplifier, Voltage series feedback, Current series feedback, Voltage shunt feedback, Current shunt feedback.

MODULE-III (9 Hours)

The basic operational amplifier (OPAMP), Off-set error voltages and currents, temperature drift of input offset voltage andcurrent, measurement of OPAMP parameters and its frequency response. Class –A large signal amplifier, higher order harmonic generation, Transformer-coupled audio amplifier, push-pull amplifier.

Digital circuits: Digital (Binary) operation of a system, OR gate, AND gate, NOT or inverter circuit, De Morgan's laws, NAND and NOR DTL gates, HTL gate, TTL gate, RTL and DCTL.

MODULE-IV (6 Hours)

Binary codes: BCD codes, gray codes, ASCII Character Code, Boolean Algebra & Logic gates: Axiomatic definition of Boolean algebra.Property of Boolean algebra, Boolean functions, Canonical & standard form; min terms & max terms, standard forms; Digital Logic Gates, Multipleinputs.Gate level Minimization: The Map Method, K Map up to five variables, Product of Sum simplification, Sum of Product simplification, Don't care conditions.

MODULE-V (9 Hours)

Combinational digital systems: Standard gate assembles, Binary adder, arithmetic functions, Decoder/Demultiplexer, Data selector/Multiplexer, Encoder.

Sequential digital systems: A 1-bit memory, Flip-flops, shift registers, Ripple (Asynchronous) counters, Synchronous counters, Application of counters.

TEXT BOOKS

[1]. Milliman. J, Halkias. C and Parikh. C.D., "Integrated Electronics", Tata Mc. Graw Hills 2nd Ed. 2010.

[2]. R.L Boylestad and L. Nashelsky, "Electronic Devices & Circuit Theory: Pearson Education.

[3]. M. Morris Mano, "Digital Design", PHI Publishers.

REFERENCE BOOKS

[1]. Mohammad Rashid, "Electronic Devices and Circuits", Cengage Learning Publishers.

[2]. Sergio Fransco, "Design with Operational Amplifiers& Analog Integrated Circuits", TMH Publishers.

[3]. Charles H.Roth, "Fundamentals of Logic Design", Cengage Learning Publishers.

Course Outcomes:

Upon the completion of the course, the students will able to:

CO1	Design of various types of amplifiers using BJT and FET using the concept of DC and AC analysis
CO2	Analyse the frequency response of various amplifiers. Comprehend the fundamental concepts in feedback amplifier circuits.
CO3	Acquaint with the design of logic gates using BJT.
CO4	Use the concept of Boolean algebra for the analysis and design of various combinational and sequential circuits. Design of various logic gates starting from simple ordinary gates to complex programmable logic devices.
CO5	Analyse the sequential logic circuits design both in synchronous and asynchronous modes for various complex logic and switching devices.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

MATHEMATICS-IV (Numerical Methods)

Module I: Errors and Root Extraction *(8 Lectures)*

Definition and sources of error, Propagation of errors, finding roots of algebraic and transcendental equations by Bisection method, Newton’s method, Secant method, fixed point iteration method.

Module I: Interpolation*(8 Lectures)*

Interpolation, Lagrange’s interpolation, Newton’s divided differences, Forward differences, Backward differences, Central differences, Interpolation error.

Module I: Numerical integration *(8 Lectures)*

Numerical integration: Newton-Cotes Integration formula (without derivation), Trapezoidal rule, Simpson’s rule, Gaussian quadrature, Errors in Numerical Integration.

Module I:* Numerical Solution of Differentianal Equations *(8 Lectures)

Solution of ODE's: Euler's method, Improved Euler's method, Runge-Kutta Methods of order-2 and 4.

Module I:* Numerical Solution of system of linear equations*(8 Lectures)

Numerical Solution of system of linear equations, Gauss Elimination method, LU decomposition, Gauss-Jordan Elimination method, Gauss Jacobi and Gauss-seidal iteration methods

Text Books:

1. An introduction to numerical analysis, Jain, Iyengar and Jain, New AgeInternational
2. Numerical Analysis, B. S. Grewal, Khanna Publishers

Course Outcomes:

Students will be able to:

CO 1: find the roots of algebraic and transcendental equations

CO 2: compute an interpolating polynomial for a given set of data

CO 3: apply numerical integration methods for computing definite integrals

CO 4: solve ordinary differential equations (IVP) by using numerical methods

CO 5: find approximate solutions for system of linear equations

Economics for Engineers

Module-1:

Theory of Demand: Demand and Utility, Demand function and the factors determining demand, Law of Demand, Reasons for downward sloping demand curve, Exceptions to the law of demand. The market forces of Supply and Demand, Elasticity of demand and its application, Utility analysis: cardinal and ordinal measurability of utility, Assumptions of cardinal utility analysis, law of diminishing marginal utility, Consumer's equilibrium: Principle of equi-marginal utility

Module-2:

Indifference curve analysis of demand: Concepts, properties, Equilibrium of the consumer, Price Consumption Curve (PCC) and Income Consumption Curve, Decomposition of price effect into income effect and substitution effect, Revealed preference hypothesis, Individual choice under Risk and Uncertainty: St. Petersburg paradox and Bernoulli's hypothesis, Neumann-Morgenstern method of constructing utility index, Friedman-Savage hypothesis, Markowitz hypothesis

Module-3

Production function: short run analysis, Total product, Average product and Marginal product, output elasticity of input, law of variable proportion, Long run production function: Isoquants and concepts of returns to scale, Optimum factor combinations,Homogeneous Production Function, Cobb–Douglas production function, CES Production function, Cost Analysis: Concepts, Accounting cost, Fixed and variable cost, opportunity cost, Short run and long run cost curves, Relationships between average cost and marginal cost

Module-4

Market and its classifications, Perfect competition: Characteristics, Short run and long run equilibrium of firm under perfect competition. Monopoly market: Price and output determination. Modern theories of firms: Baumol's theory of sales revenue maximisation, Bain's limit pricing model

Module-5

Time value of money: use of cash flow diagram, Annual economic worth, present worth, future worth, Internal Rate of Return (IRR), Net Present Value (NPV), Payback period method, Analysis of public projects: Cost-Benefit analysis, cost effectiveness

Reference Books:

1. Koutsoyiannis, A. (1979). Modern Microeconomics. The Macmillan Press Ltd., London
2. Varian, H. R. (1992). Introduction to Micro Economic Analysis, Norton and company, New York
3. Salvatore, D. (2008). Microeconomics: theory and applications. Oxford University Press
4. Pindyck, R. S., D. N. Rubinfeld and P. L. Meheta (2009). Microeconomics, Pearson India, New Delhi
5. Panneerselvam, R.(2007). Engineering Economics, Prentice-Hall of India, New Delhi
6. Henderson, J. M. and R. E. Quant (2011). Microeconomic Theory: A Mathematical Approach, Indian Higher Education, New Delhi
7. Intriligator, M. D., R. G. Bodkin and C. Hsiao(1995). Econometric Models, Techniques, and Applications, Pearson India, New Delhi

Sessional

ELECTRICAL MACHINES LABORATORY-II

List of Experiments

1. To determine the voltage regulation of alternator by EMF method
2. To determine the V curve and inverted V curve of a 3-Ph synchronous motor
3. Speed control of a 3 phase induction motor by rheostatic, cascading and pole changing methods
4. Synchronization of alternator with infinite bus.
5. No load and Blocked rotor test of three phase Induction motor.
6. Three phase connections of transformer
7. Determination of power angle characteristics of an Alternator
8. Load test of 3-Ph Induction Motor
9. Determination of Parameters of single phase induction motor
10. Separation of hysteresis and eddy current losses of single phase transformer.
11. Voltage regulation of 3 phase alternator by ZPF method.
12. Determination of Parameters of 3 phase three winding transformer and trace the waveform of Magnetizing Current & Induced e.m.f.

Course Outcomes:

Upon completion of this course, students will demonstrate the ability to:

CO1	Perform various tests on synchronous machines and to determine their characteristics.
CO2	Synchronize a given alternator to infinite bus.
CO3	Determine parameters of three phase and single phase induction motors.
CO4	Describe different losses of single phase transformer
CO5	Determine characteristics, parameters and connections of three phase transformers

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

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

Course	3	3	2	1	3	2	1	1	3	3	1	1

ANALOG AND DIGITAL ELECTRONIC LABORATORY

LISTS OF EXPERIMENTS

AE

1. Determination of the frequency response of Low pass filter.
2. Determination of the frequency response of High pass filter.
3. Study of different clipper and clamper circuits
4. Study of output characteristics of FET.
5. Study of Class A Amplifier.
6. Study of Class B Amplifier.
7. RC phase shift oscillator and to observe its output waveform

DE

1. Verification of Truth table of logic gates and verification of Demorgan's Theorems.
2. Realization of half adder, full adder, half subtractor and full subtractor.
3. Design and implementation of multiplexer using logic gates.
4. Realization of S-R and J-K flip flop using 7400.
5. Design of 3-bit asynchronous counter and mod-N counter.
6. Design of SISO, SIPO, PISO, PIPO shift registers.
7. Application of multiplexer: - design of full adder using DUAL MUX IC.

Course Outcomes:

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

CO1	Demonstrate the operation of basic filter circuits, clipper and clamper circuits.
CO2	Demonstrate the characteristics of transistors.
CO3	Implement different power amplifier circuits.
CO4	Design combinational circuits such as adder, subtractor and multiplexers.
CO5	Design of sequential circuits such as FFs, counters and shift registers.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

Fifth Semester

ELECTRICAL POWER TRANSMISSION AND DISTRIBUTION

Syllabus:

MODULE-I (8 HOURS)

General Introduction to power transmission by D.C. and A.C. overhead lines Constants: Resistance, inductance and capacitance of single and three phase lines with symmetrical and unsymmetrical spacing transposition, charging current, skin effect and proximity effect.

MODULE-II (8 HOURS)

Performance of transmission Lines: Analysis of short, medium and long lines, equivalent circuit, representation of the lines and calculation of transmission parameters, use of static or synchronous condensers for improvement of regulation. Corona: Power loss due to corona, practical importance of corona, and inductive interference with neighboring communication lines, use of bundled conductors in E.H.V. transmission lines and its advantages.

MODULE-III (8 HOURS)

Overhead line Insulators: Voltage distribution in suspension type insulators, method of equalizing, voltage distribution, economic use of insulators. Mechanical Design of Overhead Transmission Line, Sag and stress calculation, tension and sag at erection, effect of ice and wind, vibration dampers Under Ground Cable: Type and construction, grading of cables, capacitance in 3 core cables and dielectric loss.

MODULE-IV (8 HOURS)

Distribution System: types of distributors and feeders (radial & ring), voltage drop and load calculation for concentrated and distributed loads, Primary and secondary distribution network, Capacitor placement in distribution network, Distribution system planning, Service area calculation.

MODULE-V (8 HOURS)

Substation &Earthing: Types of substations, arrangement of bus-bars and control equipment, solid earthing, resistance earthing and Peterson coil Per unit system one-line diagram Power flow through transmission line, Power circle diagram, Series and shunt compensation. Introduction to Flexible AC Transmission System (FACTS), SVC, TCSC, SSSC, STATCOM and UPFC

BOOKS

1. John J Grainger, W. D. Stevenson, “Power System Analysis”, TMH Publisher.
2. J. Nagrath& D. P. Kothari, “Power System Analysis”, TMH Publisher REFERENCE BOOKS
3. S. N. Singh, “Electrical Power Generation, Transmission and Distribution”, PHI Publishers.

4. AbhijitChakrabarti, SunithaHalder, "Power System Analysis, Operation and Control, PHI Publishers

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Compute the transmission line parameters and evaluate performance.
CO2	Analyze the short, medium and long lines transmission line and the effect of corona.
CO3	Perform mechanical design and evaluate line insulators and underground cables.
CO4	Evaluate performance of primary and secondary distribution systems.
CO5	Describe types of sub-stations, earthing schemes and bus-bar schemes.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

CONTROL SYSTEM-I

MODULE-I

Scope of control system Engineering, Various Classification of Control System, Closed Loop Control Versus Open Loop Control, Mathematical model of physical systems, transfer function, block diagram algebra, signal flow graph (SFG), Mason's gain formula. Feedback Characteristics: Types of feedbacks, effect of degenerative feedback on control system, regenerative feedback, Application of Control system to engineering and non-engineering problem.

MODULE-II

Time domain analysis: Standard test signals: Time response of 1st. order systems to unit step and unit ramp inputs. Time response of second order systems to unit step input. Time response specifications. Steady state errors and error constants of different types of control systems Generalized error series method, Application of MATLAB and its Tool Box for time response analysis. Effect of poles and zeros on system response.

MODULE-III

Concepts of stability: Necessary conditions of stability, Hurwitz stability criterion, Routh stability criterion, application of Routh stability criterion to linear feedback systems, Relative stability Analysis. Root locus techniques: Root locus concepts, rules for construction of root loci, determination of roots from root locus, root contours, systems with transportation lag, Root locus plots with MATLAB.

MODULE-IV

Frequency domain analysis: Introduction, Polar plots, Bode plots, determination of stability from Bode plots, Nyquist stability criterion, application of Nyquist stability criterion to linear feedback systems, Log magnitude versus phase plots, Use of MATLAB for plotting Bode &Nyquist diagram. Closed loop frequency response: Constant M circles, constant N circles, use of Nichols chart.

MODULE-V

Controllers: Proportional, derivative and integral control actions, PD, PI and PID controllers and their applications to feedback control systems, PID controller gains tuning by Zeigler-Nichols method. 2-Degree-of-freedom control.

Sensitivity transfer functions (S and T) and their significance: Measure of loop robustness in terms of the peaks of sensitivity and transfer functions for any PID compensated system.

TEXT BOOKS

1. K. Ogata, “Modem Control Engineering”, PHI Publishers.
2. I.J. Nagrath, M. Gopal, “Control Systems Engineering”, New Age International Publishers.
3. Norman S. Nise, “CONTROL SYSTEMS ENGINEERING”, John Wiley & Sons.

REFERENCE BOOKS

1. G.F.Franklin, J.D.Powell, A. Emami, Naeini, “Feedback Control of Dynamic Systems”, Schaum’s Outlines, TMH Publishers.
2. B.C.Kuo, F. Golnaraghi, “Automatic Control Systems”, John Willey & Sons.

Course Outcomes:

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

CO1	Implement mathematical model of a physical system and its transfer function.
CO2	Compute steady state error for different standard test signals and estimate time domain performance indices.
CO3	Describe stability analysis using Routh-Hurwitz stability criterionandroot locus.
CO4	Evaluate frequency domain analysis using Bode plot and Nyquist criteria.

CO5	Design different controllers including PI, PD and PID controllers

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

POWER ELECTRONICS

Module-I (8 hours)

Power Electronic Devices: Static and Dynamic characteristics of Power Diodes, Power BJTs, Power MOSFETs, Insulated Gate Bipolar Transistors (IGBT), Thyristor Family (SCR, DIAC, TRIAC, GTO, MCT). Thermal viewpoint. Thyristor Protection, cooling and mounting techniques. Safe Operating Area and different current and voltage ratings. Triggering and basics of driver circuits of thyristors, Different types of commutation schemes: Natural and Forced commutation.

Module-II (8 hours)

AC-DC Rectifiers: Uncontrolled rectifiers. 1-Phase Half & Full Wave Controlled Rectifier with various kinds of loads (R, R-L-E (motor)). Midpoint and Bridge type converters. Half Controlled and Fully Controlled Bridge circuits, different waveforms, Input Line Current Harmonics, Power factor, current distortion and displacement factors- Inverter Mode of Operation. Continuous and discontinuous modes, Effect of source inductance assuming constant load current. Effect of freewheeling diode. Three phase bridge converters for different types of load with constant load current, different waveforms.

Module-III (8 hours)

DC-DC converter: Classification of types of choppers, One, Two and Four quadrant operations, Step up and down choppers, concepts of duty ratio and average voltage, power circuit of buck & boost converter, analysis and waveforms at steady state, duty ratio control of output voltage.
AC-AC Converters: Single-phase mid-point and bridge types of step-up and step-down Cycloconverter. Single-phase AC Voltage regulators and its basic analysis.

Module IV (7 hours)

DC-DC Regulators: Generic Linear Regulator. Different Topologies: Shunt, series, modified shunt, negative voltage regulator, protection.
Switch Mode Power Supply: Basic scheme of SMPS and its difference & advantages over linear regulators. Different types of SMPS with single and bidirectional core excitation. Basic steady state operation and analysis of Forward and Flyback converters.

Module-V (8 hours)
DC-AC Converters: Single-phase Half and Full bridge Inverter, Pulse Width Modulated (PWM) technique for voltage control, SPWM Technique 1-phase inverters, Three-phase Voltage Source Bridge type of Inverters. (120 and 180 Degree conduction modes), Current Source Inverter (Single-phase CSI with ideal switches, Single-phase capacitor commutated CSI and Single-phase auto-sequential commutated CSI).
Applications: UPS, Induction Heating, Electronic Ballast, AC/DC drives speed control.

Text Books:
1. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
2. P. S. Bimbhra, Power Electronics, Khanna Publishers.
Reference Books:
1. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
2. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.

Course Outcomes:
Upon completion of the course, the students will be able to:

CO1	Describe power switching devices and their drive circuits.
CO2	Analyze and evaluate the performance of thyristor rectifiers.
CO3	Express and evaluate the performance of AC-AC and DC-DC converters
CO4	Analyze and evaluate the performance of DC-DC linear regulators and SMPS.
CO5	Analyze and evaluate the performance of single phase and three phase inverters.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

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

Course	3	3	2	1	1	2	1	-	-	-	-	1

Professional Elective - I

SIGNALS & SYSTEMS

Module-I (7 hours)

Introduction of Signal and System: Introduction of Signals, Classification of Signals, General Signal Characteristics, Energy & Power Signal, Continuous-Time Signals, Discrete-Time Signals. Basic System Properties, Systems with and without memory, Invertibility, Casuality, Stability, Time invariance, Linearity.

Module-II (10 hours)

Convolution: Linear Time Invariant (LTI) Systems, Discrete Time LTI Systems, Convolution representation of Linear Time-Invariant Discrete-Time Systems, Convolution Representation of Linear Time-Invariant Continuous-Time Systems, Properties of convolution, Properties of LTI Systems.

Fourier Representations for Signals: Representation of Discrete Time Periodic signals, Continuous Time Periodic Signals, Discrete Time Non Periodic Signals, Continuous Time Non-Periodic Signals, Properties of Fourier Representations.

Module-III (8 hours)

Frequency Response of LTI Systems: Frequency Response of LTI Systems, Fourier Transform representation for Periodic and discrete time Signals, Sampling, reconstruction, Discrete Time Processing of Continuous Time Signals, Fourier Series representation for finite duration Non-periodic signals.

Modulation: Modulation Types and Benefits, Full Amplitude Modulation, Pulse Amplitude Modulation, Multiplexing, Phase and Group delays

MODULE-IV (7 hours)

Representation of Signals using Continuous Time Complex Exponentials: Laplace Transform, Unilateral Laplace Transform, its inversion, Bilateral Laplace Transform, Transform Analysis of Systems.

MODULE-V (7 hours)

Representation of Signals using Discrete Time Complex Exponentials: The Z-Transform, Properties of Region of convergence, Inverse Z-Transform, Transform Analysis of LTI Systems, Unilateral Z-Transform.

TEXT BOOKS

[1]. Simon Haykin and Barry Van Veen, "Signals and Systems", John Wiley & Sons Publisher.

[2]. Alan V. Oppenheim, Alan S. Will sky, with S. Hamid, S. Hamid Nawab, "Signals and Systems", PHI Publisher.

REFERENCE BOOKS

[1]. Hwei Hsu, "Signals and Systems", Schaum's Outline TMH Publisher.

[2]. Edward w. Kamen and Bonnie S. Heck, "Fundamentals of Signals & systems using Web and MATLAB", PHI Publisher

Course Outcomes:
Upon completion of the course, the students will be able to:

CO1	Describe different types of signals and systems.
CO2	Perform convolution of LTI system and apply Fourier transforms
CO3	Apply modulation techniques and evaluate frequency response of LTI system.
CO4	Analyze signals using Laplace Transform techniques
CO5	Analyze signals using Z Transform techniques

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

ELECTROMAGNETIC FIELD THEORY

PREREQUISITES

Coordinate Systems, Vector Algebra, Vector Calculus.

MODULE I (8 Hours)

Fields due to Different Charge Distributions, Gauss Law and Applications, Electric Potential, Relations Between E and V, Energy Density. Convection and Conduction Currents. Continuity Equation, Polarization of Dielectrics, Boundary Conditions. Poisson's and Laplace's Equations; Capacitance.

MODULEII(8 Hours)

Biot-Savart's Law, Ampere's Circuital Law and Applications, Magnetic Flux Density. Magnetic Scalar and Vector Potentials. Forces due to Magnetic Fields. Magnetic Boundary Conditions. Inductance & Mutual Inductance.Faraday's Law and Transformer EMF, Displacement Current Density, Maxwell's Equations.

MODULEIII(8 Hours)

Uniform Plane Waves, Wave Equations, Wave Propagation in Lossless and Conducting Media, Conductors & Dielectrics. Wave Polarization. Reflection and Refraction of Plane Waves – Normal and Oblique Incidences for both Perfect Conductor and Perfect Dielectrics.

MODULEIV(8 Hours)

Poynting Vector and Poynting Theorem – Applications.Types, Parameters, Transmission Line Equations, Primary &Secondary Constants, Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities, Infinite Line Concepts.

MODULEV(7 Hours)

Introduction to Waveguides, TE Modes, Waveguide Equation, Cut-Off Frequency. Elements Of Antenna Theory.

TEXT BOOKS:

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 4 th Edition, Oxford University Press Inc. First India edition, 2009.
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', Tata McGraw Hill 8th Revised edition, 2011.
3. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.

4. Bhag Singh Guru and Hüseyin R. Hiziroglu "Electromagnetic field theory Fundamentals", Cambridge University Press; Second Revised Edition, 2009.

Course Outcomes:
Upon completion of the course, the students will be able to:

CO1	Describe the concepts of electrostatics, electrical potential, energy density and their applications.
CO2	Apply the principles of electrostatics to the solutions of problem relating to magnetic field and electric potential , boundary conditions & magnetic energy density.
CO3	Apply the concepts of Faraday's law, induced emf and Maxwell's equations.
CO4	Apply knowledge on concepts of Poynting theorem and operation of transmission lines.
CO5	Describe the basic principles of waveguides and antenna.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

INDUSTRIAL POWER ELECTRONICS

Module-I (8 Hours)
Conventional DC and AC Traction: Electric traction services, Nature of traction load, Coefficient of adhesion, Load sharing between traction motors, Main line and suburban train configurations, Calculation of traction drive rating and energy consumption. Important features of traction drives, Conventional DC and AC traction drives, Diesel electric traction.

Module-II (8 Hours)
Static converters for Traction: Semi-conductor converter controlled drive for AC traction, Semiconductor chopper controlled DC traction. Illumination: Nature of light, Basic laws of illumination, Light sources and their characteristics, Light production by excitation and ionization, Incandescence and fluorescence, Different types of lamps, Their construction,

Operation. Electric Heating: Introduction to electric heating, Advantages of electric heating, Resistance heating, Temperature control of furnaces, Induction and dielectric heating.

Module-III (7 Hours)
Power Supplies: Performance parameters of power supplies, Comparison of rectifier circuits, Filters, Regulated power supplies, Switching regulators, Switch mode converter.

Module-IV (8 Hours)
Power factor Control: Static reactive power compensation, Shunt reactive power compensator, Application of static SCR controlled shunt compensators for load compensation, Power factor improvement and harmonic control of converter fed systems, Methods employing natural and forced commutation schemes, Methods of implementation of forced commutation.

Module-V (8 Hours)
Motor Control: Voltage control at constant frequency, PWM control, Synchronous tap changer, Phase control of DC motor, Servomechanism, PLL control of a DC motor.

TEXT Books

[1]. Dubey, G.K., Power Semiconductor Controlled Drives, Prentice Hall inc. (1989).
[2]. Paul, B., Industrial Electronic and Control, Prentice Hall of India Private Limited (2004).
[3]. J.M.D. Murphy, F.G. Turnbull, Power Electronic Control of Ac Motors, Pergamon (1990).
[4]. Sen, P.C., Thyristor DC Drives, John Wiley and Sons (1981).

COURSE OUTCOMES
Upon completion of the course, the students will be able to:

CO1	Simulate and analyze the semiconductor controlled ac and DC drive system.
CO2	Design and develop an illumination system for domestic, industry and commercial sites.
CO3	Design an electric heating system for industrial purposes.
CO4	Equip the skill to design and develop a regulated power supply
CO5	Simulate and analyze the series and shunt compensators for power factor improvement in drive system

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1

CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

RENEWABLE ENERGY SOURCES

Module-I (10 hours)

Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts, Distributed generation.

Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications.

Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing and economics. Peak power operation. Standalone and grid interactive systems.

MODULE-II (8 HOURS)

Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

MODULE-III (7 HOURS)

Energy storage and hybrid system configurations: Energy storage, Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Flywheel-energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors.

MODULE-IV (7 HOURS)

Grid Integration: Standalone systems, Concept of Micro-Grid and its components, Hybrid systems – hybrid with diesel, with fuel cell, solar-wind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics, Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling. Effect on power quality, harmonic distortion, voltage transients and sags, voltage flickers, dynamic reactive power support. Systems stiffness.

Module-V (7 Hours)

Small Hydro Systems, Bio-Mass and Bio-Fuels, Tidal power: Tidal phenomena, historical background, basic aspects of tidal power development and tide mills; Tidal power project components and types, Energy from Ocean Waves and Ocean thermal energy conversion technologies: Basic principle, System components.

Text Books

[1] Renewable Energy Resources by by John Twidell, Tony Weir, Routledge, 3rd Edition.
[2] Sustainable Energy- J.W. Tester, E.M. Drake, M. J. Driscoll, M. W. Golay , W. A. Peters, MIT Press, 2nd Edition.

Reference Books

[1] Energy Technology Nonconventional, Conventional & Renewable-Sunil S. Rao and Dr. B.B. Parulekar, Khanna Publishers.
[2] Renewable energy sources and emerging technologies -D.P. Kothari, K.C. Singal, and R. Ranjan, PHI Learning Pvt. Ltd.

Course Outcomes:

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

CO1	Describe the concept of energy security, energy sustainability and distributed generation and the relevance of solar power system.
CO2	Analyze the principles and components of wind energy systems.
CO3	Evaluate various energy storage devices for their suitability.
CO4	Describe the principle and components for small hydro, biomass, tidal, wave energy extraction.
CO5	Analyze grid integration issues of renewable energy systems.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

Sessional

CONTROL SYSTEMS LABORATORY

List of Experiments:

1. Study of a two-phase AC servomotor and its transfer function parameters.
2. Find the frequency response of a Lag and Lead compensator.
3. To observe the time response of a second order process with P, PI, PID control and apply PID control to a DC servomotor.
4. To study the characteristic of a relay and analyze the relay control system (Phase Plane).
5. Study of a linear system simulator
6. Study of feedback characteristic using Amplidyne
7. To study digital control of a simulated system using an 8 bit microprocessor

Course Outcomes:

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

CO1	Describe the operation of two-phase AC servomotor its transfer function.
CO2	Design Lag and lead compensator using frequency response.
CO3	Analyze nonlinear system using relay control system.
CO4	Construct feedback characteristic using Amplidyne.
CO5	Demonstrate the operation of digital control systems.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	3	2	1	1	3	3	1	1

POWER ELECTRONICS LABORATORY

Syllabus:

1. Familiarization with power electronics components. (SCR, IGBT, MOSFET, GTO, BJT) & Draw the V-I Characteristics of BJT, MOSFET, SCR.
2. Study of Single phase Full and Half wave converters with R and R-L-E(Motor) loads with and without freewheeling action
3. Study of Three Phase Full and Half wave converters with R and R-L-E(Motor) loads
4. To study different triggering circuits for thyristors (Cosine Law & UJT Triggering)
5. To study single phase AC regulator using Triac (R & R-L Loads)
6. To study the single phase cycloconverter with R and R-L Loads
7. To study IGBT based PWM Inverter.
8. To study the speed control of DC motor using single-phase full wave converter.
9. DC Motor speed control by single quadrant chopper circuit.
10. To study a transistorized PWM Inverter.

Course Outcomes:

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

CO1	Demonstrate power electronics components and their V-I Characteristics.
CO2	Produce waveforms across the loads and switches.
CO3	Implement triggering circuits for power electronic devices.
CO4	Demonstrate operation of AC-DC and AC-AC converters.
CO5	Demonstrate operation of Inverter circuits.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

<u>SIGNALS & SYSTEMS LAB</u>

(Use MATLAB CONTROL SYSTEM and SIGNAL PROCESSING TOOL BOXES)

1. Generation of square, triangular, exponential, sinusoidal signals and step, Impulse and RAMP functions.
2. Verification of time shifting, time scaling and reflections on square, triangular, exponential, sinusoidal, ramp, impulse and step signal.
3. Evaluation of convolution of finite –duration discrete time signals and verification of convolution properties.
4. Evolution of convolution integral of given signals.
5. Compute the discrete time Fourier transform of given sequence.
6. Frequency response of LTI Systems from Impulse response.
7. Frequency response of LTI systems Describes by differential or difference Equations.
8. Generation of AM wave and analysing its frequency content.
9. Determination of frequency response from Poles and Zeros.
10. . Pole- Zero Plot in the Z-plane and determination of magnitude response.
11. Find the impulse response of a system described by Z-transform function.
12. Implementation of Decimation and Interpolation concepts

Course Outcomes:
Upon completion of the course, the students will:

CO1	Describe various elementary signal and verify its independent variable properties.
CO2	Express the concept of convolution of LTI system.
CO3	Describe the basics of modulation and frequency response of LTI system.
CO4	Apply the knowledge how to use the Laplace Transform for representing signal.
CO5	Apply the knowledge how to use the Z Transform for representing signal

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	3	2	1	1	3	3	1	1

Sixth Semester

SWITCH GEAR AND PROTECTION

Module-I (8 Hours)
Protective Devices: Philosophy of protection, Nature, Causes and consequences of faults, Zone of protection, Requirements of a protective scheme, Basic terminology components of protection scheme. Relay classification, Principle of different types of electromagnetic relay. General equation of phase and magnitude comparators, Duality of comparators.

Module-II (7 Hours)
Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination, Directional Overcurrent relays, Distance relay, Differential relays.

Module-III (8 Hours)
Generator protection: Biased differential protection, restricted earth fault protection, Field suppression, Negative sequence protection, Earth fault detection in rotor circuit.
Transformer protection: Biased differential protections, restricted earth fault protection, Buchholz relay Protection of combined transformer and alternator.
Feeder Protection: Over current and earth fault protection, Distance protection, Pilot wire protection, Carrier current protection.
Bus bar Protection, Bus Bar arrangement schemes.

Module-IV (8 Hours)
Circuit Breakers: Formation of arc during circuit breaking. Characteristics of electric arc. Theories of arc Interruption. Recovery and restriking voltage, interruption of capacitive and inductive currents. Current chopping. Principle of A.C. and D.C. circuit breaking requirements of good circuit breaker circuit breaker rating. Different types of circuit breakers. Air break and Air blast circuit breaker. Plain break and controlled break all circuit breakers. Minimum oil circuit breakers. Vacuum circuit breaker, SF6 circuit breaker. D.C. Circuit breaker. H.R.C. Fuse: Construction and characteristics. Arrangement of Bus bar, Circuit breaker and isolator.

MODULE-V (8 Hours)
Elementary idea about digital & numerical protection, Protection against surge-surge absorber, Surge-diverter, Under-frequency, undervoltage and df/dt relays, Out-of-step protection, Effect of Power Swings on Distance Relaying.
Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.

TEXT BOOKS

1. Van C Warrington, “Protective Relays-Vol.-I & II”, John Wiley & Sons Publisher.
2. Ravindranath, M.Chander, “Power System Protection and SwitchGear”, Wiley Eastern Ltd.
3. Y. G.Paithankar and S. R. Bhide, “Fundamentals of power system protection

REFERENCE BOOKS

1. T S Madhav Rao, “Power System Protection”, TMH Publication.
2. J. L. Blackburn, “Protective Relaying: Principles and Applications”, Marcel Dekker, New York, 1987.
3. A.G. Phadke and J. S. Thorp,“Synchronized Phasor Measurements and their Applications”, Springer, 2008.

Course Outcomes:

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

CO1	Describe the different components of a protection system.
CO2	Evaluate fault current due to different types of fault in a network.
CO3	Design the protection schemes for different power system components.
CO4	Describe the principle of various types of circuit breakers.
CO5	Design digital protection systems and know the use of wide-area measurements

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

<u>MICROPROCESSOR AND MICROCONTROLLER</u>

MODULE-I (9 HOURS)

Microprocessor Architecture: Introduction to Microprocessor and Microcomputer Architecture, Pins & Signals, Register Organization, Timing & Control Module, 8085 Instruction Timing & Execution.

Instruction Set and Assembly Language Programming of 8085: Instruction set of 8085, Memory & I/O Addressing, Assembly language programming using 8085 Instruction Set.

MODULE-II (6 HOURS)

Use of Stack & Subroutines, Data transfer techniques, 8085 interrupts.

Interfacing & support chips: Interfacing EPROM & RAM Memories, 2716, 2764, 6116 & 6264, Interfacing of I/O devices with 8085, Partial address decoding for memory and I/O devices.

MODULE-III (6 HOURS)

Microprocessor Based System Development Aids, Programmable Peripheral Interface: 8255, Programmable DMA Controller: 8257, Programmable Interrupt Controller: 8259

Application: Delay calculation, square wave generation, Interfacing of ADC & DAC, Data Acquisition System.

MODULE-IV (9 HOURS)

Advanced Microprocessor: Basic features of Advance Microprocessors, Intel 8086 (16 bit processors): 8086 Architecture, Register organization, signal descriptions, Physical Memory Organization, Addressing Modes, Instruction Formats, Instructions Sets & Simple Assembly language programs, 8086 Interrupts.

Module – V (9 Hours)

Microcontroller: Introduction for Microcontrollers, Microcontrollers & Microprocessors, 8051 Microcontrollers. MCS-51 Architecture, Registers, Stack Pointer & Program Counter. 8051 Pin Description, Connections, Parallel I/O ports, Memory Organization, 8051 Addressing Modes & Instructions, 8051 Assembly Language Programming Tools. Simple application: Delay calculation, square wave generation.

Books:

[1]. 0000 to 8085 Introduction to Microprocessor for Scientists & Engineers by Ghosh & Sridhar, PHI

[2]. Fundamentals of Microprocessor & Microcontroller by B.RAM, Dhanpat Rai Publications.

[3]. Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing) by A.K.Roy&K.M.Bhurchandi- TMH Publication.

[4]. Microcontrollers, theory and applications, TMH, Ajay V. Deshmukh.

[5]. Microprocessor and Microcontroller by N Senthil Kumar, M. Saravanan and S. Jeevananthan, Oxford University Press.

Course Outcomes:
Upon completion of the course, the students will be able to:

CO1	Demonstrate knowledge on microprocessor and microcontroller.
CO2	Demonstrate an ability to write assembly language programming.
CO3	Describe the basic idea about the data transfer schemes and its applications.
CO4	Apply knowledge on design of different interfacing circuits and troubleshoot interactions between software and hardware.
CO5	Express on design of microprocessor/microcontroller-based systems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

Professional Elective – II

COMPUTER SYSTEM ARCHITECTURE

Syllabus

Module-I (09 Hours)

Introduction: Basic Organization of Computers, Classification Micro, Mini, Mainframe and Super Computer. System Bus and Interconnection, PCI, Computer Function, I-Cycle, Interrupt and Class of Interrupts, Von-Neumann M/c: Structure of IAS.ComputerArithmetic: Data Representation: Fixed Point Representation, Floating Point Representation. Addition and Subtraction, Multiplication Algorithm, Division Algorithm, Floating Point Arithmetic Operation, Decimal ArithmeticOperation.

Module-II (05 Hours)

CPUOrganization: Fundamental Concepts: Fetching and storing a word in Memory, Register Transfer, performing an Arithmetic & Logic Operation, Execution of a Completes, Branching.

Module-III (09 Hours)

GeneralRegisterOrganization: Control word, Examples of Microsoft, Stack Organization, Register Stack, Memory Stack, RPN, Evaluation of Arithmetic Expression using RPN, Instruction Format: Three Address, Two Address, One Address and Zero Address Instruction, Addressing Modes: Types of Addressing modes, Numerical Examples, Program Relocation, Compaction, Data Transfer & Manipulation: Data transfer, Data Manipulation, Arithmetic, Logical & Bit Manipulation Instruction, Program Control: Conditional Branch Instruction, Subroutine, Program Interrupt, Types of Interrupt, RISC & CISC Characteristic. Control Unit Operation: Hardware Control & Micro Programmed Control, Introduction to Pipelining.

Module-IV (06 Hours)

Input/outputOrganization: Peripheral Devices, input – output Interface, I/O Bus, Interface Module, Asynchronous Data Transfer, Strobe Control, Handshaking, Asynchronous Serial Transfer, Asynchronous Communication Interface, Modes of Transfer: Programmed I/O, Interrupt Driven I/O, Direct Memory Access (DMA), DMA Controller, I/O Channel& Processor. Priority Interrupt: Daisy Chaining Priority, Parallel Priority Interrupt.

Module-V (10 Hours)

MemoryOrganization: Computers Memory System Overview, Characteristics of Memory System, The Memory Hierarchy, Semi-Conductor Main Memory types, Organization, Memory cell Operation. Cache Memory: Cache Principles, Elements of Cache Design, Cache Size, Mapping function, Replacement Algorithm, LRU, FIFO, LFU, Write policy. Number of Caches: Single versus two level caches, Pentium Cache Organization. Associative Memory: Hardware Organization, Match Logic. Read Operation, Write Operation, Auxiliary Memory: Magnetic Disks, Magnetic Tape. Virtual Memory: Paging, Paging h/w, Address Mapping using pages, Segmentation h/w, Demand Paging, Memory Managementh/w.

Text Books:

[1]. William Stallings, “Computer Organization & Architecture”, 7thEdition,PHI.
[2]. Morris Mano, “Computer System Architecture”, 3rdEdition,PHI.

Reference Books:

[1]. V.CarlHamacher, Z.G.Vranesic, and S.G.Zaky, “Computer Organization”, 5th Edition, McGrawHill.
[2]. John P. Hayes, “Computer Architecture and Organization” 3rd Edition, Mc Graw Hill

InternationalEditions.
[3]. D.A.Patterson&J.L.Hennessy , "Computer Organization & Design" , 3rd Edition Morgan Kaufmann Publishers(Elseviers)
[4]. Hwang and Briggs, "Computer Architecture and Parallel Processing", Mcgraw Hill 1985.

Course Outcomes:
Upon completion of the subject the students will be able to:

CO1	Describe about architecture of Computer.
CO2	Recognize the CPU organization.
CO3	Apply the knowledge Register organization.
CO4	Express the I/O organization.
CO5	Compile the memory organization.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

CONTROL SYSTEM-II (PE-II)

MODULE-I (6 HOURS)

Digital Control Systems: Advantages and disadvantages of Digital Control, Representation of Sampled process, The z-transform: The Z-transform, Z-transform of Elementary functions, Important properties and Theorems of the Z-transform. The inverse Transform, Z Transform method for solving Difference Equations.

MODULE-II (8 HOURS)

Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Pulse Transfer function: Starred Laplace Transform of the signal involving Both ordinary and starred Laplace Transforms; General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems. Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane: Stability analysis by use of the Bilinear Transformation and Routh stability criterion, Jury stability Test.

MODULE-III (8 HOURS)

State Variable Analysis and Design: Introduction, Concepts of State, Sate Variables and State Model, State Models for Linear Continuous-Time Systems, State-Space Representation Using Physical Variables, State – space Representation Using Phase Variables, Phase variable formulations for transfer function with poles and zeros, State – space Representation using Canonical Variables, Derivation of Transfer Function for State Model. Diagonalization: Eigenvalues and Eigenvectors, Generalized Eigenvectors.

MODULE-IV (8 HOURS)

Solution of State Equations: Properties of the State Transition Matrix, Computation of State Transition Matrix , Computation by Techniques Based on the Cayley-Hamilton Theorem, LT method, Sylvester's Expansion theorm. Concepts of Controllability and Observability: Controllability, Observability, Pole Placement by State Feedback, Observer based state feedback control.

State Variables and Linear Discrete – Time Systems: State Models from Linear Difference Equations/z-transfer Functions, Solution of State Equations (Discrete Case), An Efficient Method of Discretization and Solution, Derivation of z-Transfer Function from Discrete-Time State Model.

MODULE-IV (8 HOURS)

Nonlinear Systems: Introduction, Behaviour of Nonlinear Systems, Common Physical Non-linarites, The Phase-plane Method: Basic Concepts, Singular Points, Stability of Nonlinear System, Construction of Phase-trajectories, The Describing Function Method: Basic Concepts, Derivation of Describing Functions: Dead-zone and Saturation, Relay with Dead-zone and Hysteresis, Backlash. Stability Analysis by Describing Function Method: Relay with Dead Zone, Relay with Hysteresis, Jump Resonance. Signal Stabilization.

Liapunov's Stability Analysis: Introduction, Liapunov's Stability Criterion, The Direct Method of Liapunov and the Linear System, Methods of Constructing Liapunov Functions for Nonlinear Systems

TEXT BOOKS

[1]. K. Ogata, "Modem Control Engineering", PHI Publisher.

[2]. I.J. Nagrath, M. Gopal, "Control Systems Engineering", New Age International Publishers.

REFERENCE BOOKS

[1]. Khalil H.K., 'Nonlinear Systems', Prentice Hall Publications, 3rd Edition, 2002.

[2]. K.Ogata, “Discrete Time Control System”, Pearson Education Asia Publisher.
[3]. M. Gopal, *Digital Control and State Variable Methods*, Tata McGraw-Hill

Course Outcomes:
Upon completion of the course, the students will be able to:

CO1	Perform sampling and Z transform analysis of Digital control system.
CO2	Design transfer function model of digital control system and analyze its stability.
CO3	Construct state space analysis of LTI system.
CO4	Design pole placement controller and/or observer for the given system to achieve desired specifications.
CO5	Express knowledge on Nonlinear control systems and perform stability analysis of the dynamical systems using Lyapunov method.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

DIGITAL CIRCUITS & DESIGN (PE-II)

Module-I (08 hours)
Number system& codes: Binary Number base conversion, Octal &hexadecimalnumbers, complements, signed binary numbers, binary codes-BCD codes, gray codes, ASCII Character Code, Codes for serial data transmission &storage.Boolean Algebra & Logic gates: Axiomatic definition of BooleanAlgebra. Property of Boolean Algebra, Boolean functions, Canonical & standard form; min terms & max terms, standard forms; Digital Logic Gates, Multiple inputs.

MODULE-II (08 HOURS)
Gate level Minimization: The Map Method, K Map up to five variables, Product of Sum simplification, Sum of Product simplification, don’t care conditions. NAND and NOR Implementation, AND-OR inverter, OR-AND inverter implementation, Ex-OR Function, parity generation& checking, Hardware Description Language (HDL). Combinational Logic:

Combinational Circuits, Analysis &Design procedure; Binary Adder- subs tractor, Decimal Adder, Binary Multiplier, Magnitude comparator, Multiplexers and demultiplexers, Decoders, Encoders, Multipliers, Combinational Circuits design

MODULE-III (08 HOURS)

Synchronous Sequential logic: Sequential Circuit, latches, Flip-flop, Analysis of Clocked Sequential circuits, HDL for Sequential Circuits, State Reduction &Assignment, Design procedure.

Register &Counters: Shift Register, Ripple Counters, Synchronous Counter, Asynchronous Counter, Ring Counters, Module-n Counters, HDL for Register & Counters

MODULE-IV (08 HOURS)

Memory & Programmable logic: Random Access Memory (RAM),Memory , Decoding, Error detection & correction, Read only Memory, Programmable logic array ,Sequential Programmable Devices.

Digital Integrated Logic Circuits: RTL, DTL, TTL, ECL, MOS & C-MOS Logic circuits.

MODULE-V(07 HOURS)

Digital to analog converters: weighted resistor/converter, R-2R Ladder D/Aconverter,specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit,analog to digitalconverters: quantization and encoding, parallel comparator A/Dconverter,successive approximation A/D converter, counting A/D converter, dual slope A/Dconverter,A/Dconverterusing voltagetofrequencyandvoltagetotimeconversion,specificationsofA/Dconverters, example of A/D converters.

Books

[1] Digital Design,3rd edition by M. Morris Mano, Pearson Education

[2] R.P. Jain, “Modern Digital Electronics”, TATA McGraw-Hill Publishers

References Books:

[1] D. P. Kothari | J. S. Dhillon, “Digital Circuit and Design”, PEARSON

[2] Fredriac J. Hill and Gerald R. Peterson “Introduction to Switching Theory and Logic Design”, John Wiley & Sons Publishers.

Course Outcomes:

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

CO1	Describe common forms of number representation in digital electronic circuits and to be able to convert between different representations.
CO2	Describe the gate level minimization technique by K-map and Boolean algebra and

	design of combinational circuits with its hardware implementation.
CO3	Design of sequential circuits with its hardware implementation.
CO4	Design and implement various ICs in the form of logic families. Know various programmable logic devices.
CO5	Analyze the process of Analog to Digital conversion and Digital to Analog conversion

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

EMBEDDED SYSTEM (PE-II)

MODULE – I (8 hours)

Introduction to Embedded System: What is embedded system, History of embedded systems, classification of embedded system, Major application area of embedded system, Purpose of embedded system, Typical Embedded sys: Core of embedded system, Memory, Sensors, Actuators, Communication Interface, Embedded Firmware Other system component, PCB and Passive components.

MODULE – II (8 hours)

Hardware Software co-design and programming model, Fundamental Issues in Hardware – Software co design, Computational model Embedded System, , Hardware software trade off, Embedded Hardware design and development : Analog design components, Digital Electronics component, Embedded Firmware design and development, Embedded Firmware design approach

MODULE –III (8 hours)

Introduction to unified modelling language (UML), VLSI and Integrated Circuit design, Embedded firmware development language , Programming in Embedded C.

MODULE – IV (8 hours)

Real Time operating system (RTOS) based embedded system design, Types of operating systems, Task process and threads, Multiprocessing and multi-tasking, Task scheduling, Thread and process scheduling, putting task communication, Task synchronization, Device drivers, Task synchronization, Task scheduling, Thread and process scheduling, putting task communication, Task synchronization, Device drivers, how to choose RTOS.

MODULE – V (7 hours)

Embedded system Development environment (IDE), Types of files generated on cross compilation, Dissembler / De compiler, Simulators, Emulator, Debugging, Design Case studies, Digital Clock, Battery operated smart card Reader, Automated meter reading system (AMR), Digital Camera.

TEXT Books

[1]. Shibu K.V, "Introduction to Embedded Systems",TMH Publication.
[2]. Rajkamal, "Embedded Systems –Architecture, Programming and Design", TMH Publication.

REFERENCE BOOKS

[3]. Frank Vahid, Tony D. Givargis, "Embedded System Design – A Unified Hardware/Software Introduction",John Wiley Publisher.
[4]. David E. Simon, "An Embedded Software Primer", PHI Publication.

Course Outcomes

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

CO1	Describe embedded system. Processor, memory, sensor, actuator
CO2	Design and programming model
CO3	Implement UML programming, VLSI programming, Embedded C programming
CO4	Express knowledge on Real time programming
CO5	Apply Integrated development environment and demonstrate embedded systems

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

Professional Elective - III

ELECTRIC DRIVES AND TRACTION

MODULE-I (10 HOURS)

Electrical Drives, advantages, elements of drive system, drive characteristics, criteria for selection of drive components, dynamics of motor drives, steady-state stability. Speed-torque characteristics of DC motor (starting, running, braking), size and rating of industrial motors (short time, intermittent, continuous), Mechanical considerations (enclosure, bearing transmission of drive, through chain, pulley and gears noise)

MODULE-II (8 HOURS)

Phase control of DC drive systems, steady state analysis of single-phaseconverter controlled DC motor Drive, chopper control of DC drives, Principle of operation of the chopper, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit and chopper for inversion.

MODULE-III (10 HOURS)

Speed-torque characteristics of AC motor (starting, running, braking), Speed control of VSI fed V/f and PWM control scheme of induction motor drive system – dynamic and regenerative braking, stator voltage control, rotor resistance control, Slip power recovery control, static Scherbius drives and modified Kramer drives, Introduction to vector control of induction motor.

MODULE-IV (7 HOURS)

Need for leading PF operation, Open loop VSI fed drive and its characteristics–True mode and Self-control of synchronous motor, Synchronous motor variable speed drive, Variable frequency control of multiple synchronous motor, Self control synchronous motor drive employing load commutated thyristor inverter, Sinusoidal PMAC motor drives, Brushless dc (or trapezoidal PMAC) motor drives.

MODULE-V (10 HOURS)

Advantages of Electric Traction, Mechanics of train movement, Speed - time curve for train movement, Requirement of tractive effort and T-N curve of a typical train load, Specific energy consumption & Factors affecting Adhesion & Coefficient of adhesion, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor Converter Controlled

Drives- DC Traction using Chopper Controlled Drives, DC /AC Traction employing Poly-phase motors.

Recommended Books

1. G. K. Dubey &C.R.Kasaravada ,"Power Electronics & Drives", Tata McGraw Hill,1993.
2. R. Krishnan, Electric Motor Drives - Modeling, Analysis and Control Prentice- Hall of India Pvt. Ltd., New Delhi, 2003.
3. Partab," Modern Electric Traction", Dhanpat Rai & Sons.

References

1. Ned Mohan," Power Electronics and drives", et. al, Wiley 2006
2. BimalK.Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.
3. Upadhayay J. & Mahindra S.N., "Electric Traction", Allied Publishers Ltd., 1st Ed.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Apply the knowledge of modern electrical drives for selection of motor drives.
CO2	Analyze the torque-speed characteristics of DC motors and the phase controlled and DC-DC chopper drives in motoring and braking modes.
CO3	Analyze the torque-speed characteristics of AC motors and speed control of induction motor using power electronics converters in motoring, braking and transient operations and vector control of induction motors.
CO4	Apply the power factor corrections in industrial loads and application of synchronous motor in product industries.
CO5	Evaluate the electric traction technologies and movement of electric trains and the control drives of electric motor in locomotive trains.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

ENGINEERING OPTIMIZATION

Syllabus

Module-I (8 hours)

Statement of an optimization problem, classical optimization techniques: single variable optimization, unconstrained and constrained multivariable optimization problems, Karush-Kuhn-Tucker (KKT) conditions, convex programming problem.

Module-II (8 hours)

Linear programming problem, simplex algorithm, duality, transportation model and its variants.
Nonlinear programming algorithms: direct search method, gradient method, separable programming, quadratic programming, chance constrained programming.

Module-III (8 hours)

Overview of the geometric programming problem. Dynamic programming: multi-stage decision process, computational procedure. Integer programming: solution using cutting-plane method, branch-and-bound method. Mixed-integer programming problems.

Module-IV (8 hours)

Stochastic processes: review of basic probability, empirical distributions, Monte carlo simulation. generation of discrete and continuous random variables, joint distribution and copula. Decision making under certainty, risk and uncertainty, game theory. Markov chains.

Module-V (7 hours)

Multiobjective optimization: pareto optimality, selection using fuzzy membership, weighting method, utility function method, global criterion method, goal programming method.
Concept of heuristic and meta-heuristic methods, Derivative free optimization, Genetic algorithms, neural networks, swarm optimization techniques.

Books

1. S.S.Rao, “Engineering Optimization”, 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007
2. H.A. Taha, Operations Research, An Introduction, PHI, 2008

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Describe classical optimization techniques to solve optimization problems
CO2	Construct and analyze linear and nonlinear programming problems.
CO3	Construct and analyze dynamic programming and integer programming problems.
CO4	Apply stochastic processes and tools for solving decision making problems.
CO5	Apply multi-objective optimization and evolutionary programming techniques.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

HEURISTIC OPTIMIZATION

Syllabus

Module-II (8 hours)

Introduction to Neuro, Fuzzy and Soft Computing. Fuzzy Sets : Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation and Parameterization, Fuzzy Rules and Fuzzy Reasoning, Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning , Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Input Space Partitioning and Fuzzy Modeling.

Module-III (8 hours)

Neural Networks: Introduction. Architecture. Backpropagation. Supervised Learning: Perceptrons, Adaline, Multilayer Perceptron's, Radial basis functions. Learning from Reinforcement. Unsupervised learning. The Hopfield network. The Kohonen Model. Recurrent neural networks. Deep learning. Bayesian learning. Extreme learning machines.

Module-III (7 hours)

Neuro-Fuzzy Modelling: Adaptive neuro-fuzzy information; systems (ANFIS), Hybrid Learning Algorithm, Applications to control systems and pattern recognition. Data Clustering. Support Vector Machines.

Module-IV (8 hours)
Derivative-free Optimization. Genetic algorithms: Basic concepts, encoding, fitness function, reproduction. Differences of GA and traditional optimization methods. Basic genetic programming concepts Applications.

Module-V (7 hours)
Simulated Annealing, Random Search, Downhill Simplex Search, Evolutionary Computing. Differential Evolution. Swarm optimization. Cuckoo Search and Firefly Algorithm.

TEXT BOOKS

[1]. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI Publisher.
[2]. R.Eberhart, P.Simpson and R.Dobbins, "Computational Intelligence-PC Tools", AP Professional Publishers.

REFERENCE BOOKS

[1]. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill Publisher.
[2]. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley Publisher.

Course Outcomes:
Upon completion of the course, the students will demonstrate the ability to:

CO1	Define and design fuzzy systems.
CO2	Apply neural networks for solving optimization problems
CO3	Describe the various types of neuro-fuzzy models and their applications.
CO4	Apply genetic algorithm and derivative free optimization
CO5	Apply evolutionary computing techniques.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

SENSOR TECHNOLOGY

Syllabus:

MODULE-I (7 Hours)

Measurement and Instrumentation: General concepts of Measurement, Instruments and Instrumentation, static and dynamic characteristics, error probability density function, least squares calibration curves, calibration of measuring instruments. Loading effect and two-port networks. Introduction to Sensor, Actuator, Transducer, Inverse Transducer, Smart / Intelligent Sensors: Analog and Digital Signal Conditioners. Classification of transducers.

MODULE-II (8 Hours)

Measurement of Electrical variables: Classifications and Limitations of Electromechanical Instruments. Classifications and Benefits of Digital Measuring Instruments. Hall-effect magnetometers: voltage sensor and current sensor. Proximity sensors: Capacitive and Inductive type probes/ pickups, RF probes. Optoelectronic transducers.

MODULE-III (8 Hours)

Measurement of Physical parameters: Working principle and design of conventional sensors and smart sensors to measure physical parameters like Temperature, Pressure, Level and Flow. LVDT, Strain Gauge, Vibration Transducer, Seismic measurement: displacement, velocity & Acceleration pickups, Piezo-resistive and Piezoelectric transducers; Moisture and/or Humidity sensors, Gas Sensors. Case studies.

MODULE-IV (8 Hours)

Signal Conditioning Devices: 1-arm, 2-arm and/or 4-arm active bridges; Resistive deflection bridges, Reactive deflection bridges; OPAMP based: Instrumentation amplifier, Charge amplifier & Impedance converters, V/I converter and I/V converter, Integrator & Differentiator; Filters; A/D and D/A conversions: sampling, quantization, encoding, and converters. TDM, FDM and WDM.

MODULE-V (8 Hours)

Digital Storage Oscilloscopes, DSO applications. Digital voltmeters, multi-meters and frequency meters. Signal Generators: LF signal generators; function generators; RF signal generators; sweep frequency generators and frequency synthesizers. Inductive and Capacitive measurements: Digital RCL meters, Q-meter. True RMS meter. Harmonic distortion meter.

Locating cable faults and methods of rectifying it. Introduction to EMC, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding.

Books:

1. John P. Bentley, "Principles of Measurement Systems", Third edition, Pearson India, 2017.
2. David A. Bell, "Electronic Instrumentation and Measurements", Third edition, Oxford University Press, 2013.
3. Ernest O. Doebelin and Dhanesh N. Manik, "Doebelin's Measurement Systems", Sixth edition, McGraw-Hill India, 2013.

References books:

1. James W. Dally, William F. Riley, and Kenneth G. McConnell, "Instrumentation for Engineering Measurements", Wiley student edition, Second edition, 2013.
2. Kim R. Fowler, "Electronic Instrument Design – Architecture for the Life cycle", Oxford University Press, 11th India edition, 2012.
3. ManabendraBhuyan, "Intelligent Instrumentation – Principles and Applications", CRC Press, 2012.

Course Outcome:

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

CO1	Describe the principles of measurement and instrumentation in commercial and industry environments;
CO2	Recognize mechanical or smart sensor/actuator as per specifications, and to measure the specific electrical variables in real-time;
CO3	Apply knowledge on a mechanical or smart sensor/actuator as per specifications, and to measure the physical parameters;
CO4	Express the need of the most appropriate signal conditioning (SC) devices and design of analog or digital SC circuits;
CO5	Produce idea on the need of recording and display devices along with need of communication links and safety measures as per industry standards and practices.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

Sessional

ELECTRICAL MACHINE DESIGN

Syllabus

1. To study the magnetic circuit design of electrical machines.

2. To study thermal design aspects of electrical machines.
3. To study the armature winding design of D.C machine.

4. To study the design of DC machine and preparation of design chart.

4. To study the design of transformer.

5. To study the design of induction motor.

6. To study the choice of specific magnetic & electric loadings of a synchronous motor.
(all the above-mentioned design to be computed using MATLAB software)

Essential Reading

1. A.K. Sawhney and A. Chakrabarti, *A Course in Electrical Machine Design*, Dhanpat Rai Publishers, New Delhi , 2006
2. P.S.Bimbhra, *Electrical machinery*, Khanna Publishers, New Delhi, 1975.
3. Say, Maurice George, and Eric Openshaw Taylor. *Direct current machines*. Pitman, 1986.

Course Outcomes

Upon completion of the course, the students will

CO1	Describe magnetic circuit design and thermal design aspects of electrical machine.
CO2	Design a D.C machine of any rating
CO3	Apply the knowledge on the design transformer
CO4	Express idea on design induction motor and will understand about the choice of magnetic& electric loading of a synchronous motor.
CO5	Describe application of MATLAB software to the above design problems

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

MICROPROCESSOR AND MICROCONTROLLER LAB

Syllabus:

1. Verification of basic instruction set of 8085 microprocessors.
2. Verification of additional instruction set of 8085 microprocessors.
3. Addition and subtraction of two 8-bit numbers resulting in 8/16-bit number using 8085.
4. Multiplication and division of two 8-bit numbers resulting in 8/16-bit number using 8085.
5. (a) Find smallest and largest number among ‘n’ numbers in a given data array using 8085.
   (b) Write an assembly language program of binary to gray code conversion in 8085.
6. Write a program to generate square waves of different frequencies on all lines of 8255 by the help of delay program.
7. Study of stepper motor and its operations (clockwise, anti-clockwise, angular movement and rotation in various speeds).
8. Study of different addressing modes of 8051 microcontrollers.
9. Addition and subtraction of two 16-bit numbers using 8051.
10. Multiplication and division of two 16-bit numbers using 8051.

Course Outcomes

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

CO1	Perform different mathematical operations using microprocessor.
CO2	Demonstrate an ability to write assembly language programming.
CO3	Perform different tasks using programmable devices and work with different interfacing circuits.
CO4	Demonstrate stepper motor using microprocessor.
CO5	Produce different types of waveforms.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

POWER SYSTEM LABORATORY-I

Syllabus:

1. Determination of operating characteristics of biased differential relay.
2. Determination of operating characteristics of an induction type overcurrent relay.
3. Operation and performance of Numeric Relays.
4. Operation and performance of Microprocessor based relays.
5. Study of Ferro resonance phenomenon of no-load, light load & critical load conditions.
6. Determination of A, B, C, D parameters of an artificial transmission line a transmission line.
7. Performance analysis using transmission line simulator.

Course Outcomes

Upon completion of the subject the students will be able to:

CO1	Demonstrate the operation of electromagnetic relays.
CO2	Demonstrate the operation of numeric and digital relays.
CO3	Implement relay setting.
CO4	Demonstrate ferroresonance phenomenon.
CO5	Demonstrate the determination of A, B, C, D parameters experimentally.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

Seventh Semester

HIGH VOLTAGE ENGINEERING

MODULE-I (9 HOURS)

Conduction and breakdown in gases: Ionisation processes. Townsend current growth equation. Current growth in the presence of secondary processes. Townsend's criterion for breakdown. Experimental determination of ionization coefficients. Breakdown in electronegative gases, time lags for breakdown, streamer theory of breakdown in gases, Paschen's law, Breakdown in non-uniform field and corona discharges, Penning effect, Vacuum breakdown.

MODULE-II (7HOURS)

Conduction and breakdown in liquid dielectrics: Pure liquids and commercial liquids, conduction and breakdown in liquids.

Breakdown in solid dielectrics: Introduction, Intrinsic brakdown. Electromechanical breakdown, Thermal breakdown. Solid dielectrics in practice. Applications of nanofilled materials for outdoor and indoor insulation

MODULE-III (8 HOURS)

Generation of high voltages and currents: Generation of high D.C, voltages, Generation of high alternating voltages, Generation of Impulse voltages. Tripping and control of impulse generators. Generation of Impulse currents.

MODULE-IV (7 HOURS)

Measurements of high voltages and currents: Measurement of high D.C. voltages. Measurement of high D.C. and impulse voltages. Introduction.. Measurement of high D.C. A.C. and impulse currents, cathode ray oscillographs for impulse voltages and currents measurements.

MODULE-V (8 HOURS)

High voltage testing of electrical power apparatus: Testing of insulators and bushings. Testing of isolators and circuit breakers, cables. Testing of transformers, surge diverter

Non destructive testing of materials and electrical apparatus: Introduction. Measurement of D.C. resistivity. Measurement of dielectric constant and loss factor. Partial discharge measurements.

Radio Interference measurements.

BOOKS

1. M.S. Naidu and V. Kamaraju, *High Voltage Engineering,* Tata McGraw-Hill, 5th Edition, 2018.
2. E.Kuffel, W.S. Zaengl, and J.Kuffel "High Voltage Engineering Fundamentals", Second edition 2000, published by Butterworth-Heinemann
3. C.L.Wadhwa, "High Voltage Engineering", Third Edition, New Age International Publishers, 2012

References

1. Hugh M.Ryan,(ed) "High Voltage Engineering & Testing", 3rd Edition, The Institution of Engineering and Technology, IET series. 2001
2. M. Abdel-Salam, H. Anis, A. El-Morshedy, R. Radwan, High-Voltage Engineering – Theory and Practice, 2nd edition, Marcel Dekker, Inc,(Special Indian Edition) 2010.

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	Describe various types of insulating materials (gaseous, liquids, solids, vacuum, composites) and their applications in high-voltage equipment.
CO2	Describe the breakdown phenomenon in air, solid and liquid insulation
CO3	Apply knowledge on applying techniques for generation of high voltage and high current.
CO4	Describe basic measurement of high voltage and current for testing purposes.
CO5	Describe testing high voltage electrical equipment with various testing devices

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	1	1	2	1	-	-	-	-	1

POWER SYSTEM OPERATION & CONTROL

Prerequisite Subjects

Electrical Machines, Network Theory, Power Station Engineering, Electric Power Transmission and Distribution, Control System, Power Electronics

Syllabus

Module-I (8 Hours)

Concept of real and reactive powers, Complex power, Transmission capacity, The static load flow equations(SLFE), Definition of the load flow problem, Network model formulation, A load flow sample study, Computational aspect of the load flow problem. Gauss Siedel and Newton Raphson method for power flow fast decoupled load flow.

Module-II (8 Hours)

Power System Stability: Steady State Stability, Transient stability, Swing equation, Equal area criterion for stability, critical clearing angle, point by point Methods of improvement of transient stability. Voltage stability, concept, causes and counter measures, Voltage stability indices.

Module-III (6 Hours)

Economic Operation of Power System: Distribution offload between units within a plant, Transmission losses as function of plant generation, Calculation of loss coefficients, Distribution of loads between plants with special reference to steam and hydel plants, Automatic load dispatching. Optimal Power Flow.

Module-IV (10 Hours)

Symmetrical and unsymmetrical fault analysis for power system, L-G, L-L-G, three phase fault anlaysis, Z bus Algorithm, Z bus method in fault analysis.

Module-V (8 hours)

Load frequency control, PF versus QV control, Modelling of speed governing system, Division of power system into control areas, Single area control and two area control. On load tap changing transformer and block regulating transformer, effects of regulating transformers.

Books

[1]. John J Grainger, W. D. Stevenson, *"Power System Analysis",* TMH Publication
[2]. P. Kundur, "Power System Stability and Control", TMH Publication
[3]. C. L. Wadhwa, *"Electric Power System",* New Age Publishers.

Course Outcome

Upon completion of the course, the students will demonstrate the ability to:

CO1	Compute load flow solution by using different techniques
CO2	Assess the stability of a power system.
CO3	Determine the economical load distribution between the generating buses

	incorporating the transmission losses.
CO4	Compute the state of power system following the different types of faults.
CO5	Describe automatic generation control schemes and methods to analyze active and reactive power control on a power system using simulation tools.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	1	2	1	-	-	-	-	1

Power System Analysis

SYLLABUS

Module-I (10 hours)

Power Systems Review: Review of basic concepts- per unit systems, ac circuits, phasors, power system structure and topology

System Modeling: From Detailed to Approximate Including Their Controls

Generation: generator, exciter, voltage and frequency regulators, prime-mover

Transmission systems: transformers and lines, including distributed parameter models

Loads: RL, motor drives and aggregated models

Module-II (8hours)

Power flow analysis, Optimal power flow, Solution of OPF by Gradient method, Newton's method, LP method, Security constrained OPF, Continuation power flow, Sparse matrix techniques for large scale system problems.

Module-III (8 hours)

Unit commitment of generators, Hydro-thermal coordination- hydrological coupling between hydropower stations, power balance and discharge equations, formulation of the operational planning problem, pumped storage units and their scheduling, Generation with limited energy supply, Probabilistic production simulation.

Module-IV (8 hours)

Power System Security, Contingency analysis: approximations in contingency analysis, adding and removing multiple lines, analysis of single contingencies, analysis of multiple contingencies, contingency analysis by DC model.

Module-V (7 hours)

State estimation of power systems: Method of least squares for state estimation; Estimation of power system state variables by the weighted least square estimation technique; statistical errors and bad data recognition; formation of Hessian matrix.

Recommended Books

[1]. P. Kundur, ”Power System Stability And Control”, McGraw-Hill, 1994

[2]. Olle I. Elgerd, *Electric Energy Systems Theory AN Introduction*, McGraw Hill E Pvt Ltd, New Delhi.

[3]. G.W. Stagg & A.H. EL-Abiad, “*Computer methods in power system analysis”,* McGraw Hill, 1968.

[4]. A. J. Wood & B. F. Wallenberg, *“Power generation, operation and control”,* Wiley-Interscience Publication, 2nd Edition, 1996.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Construct the power system model and simulate.
CO2	Perform optimal power flow using different techniques.
CO3	Analyze unit commitment and hydro-thermal coordination problems.
CO4	Carry out contingency analysis and ranking.
CO5	Demonstrate the state estimation in power systems.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Operation and Control of Restructured Power Systems

Module-I (8 hours)

Fundamentals of Electricity Markets and Energy Auctions, necessityfor restructuring the power industry. Review of Concepts- marginal cost of generation, least-cost operation, incremental cost of generation. Components of restructured systems, independent system operators,functions and responsibilities, Market models (pool, bilateral andmultilateral). Market power and imperfect competition, Supply and demand functions, equilibrium.

Module-II (8hours)

OPF: Role in vertically integrated systems and in restructured markets. Transmission Open Access, Power wheeling transactions and marginal costing, transmission costing, Transmission pricing paradigms- embedded cost based, incremental cost based methods. Optimal bidding. Power flow tracing. LMP based markets, auction models and price formation, price based unit commitment.Tagging electricity transactions.

Module-III (8 hours)

Transmission Congestion Management and Transmission Rights, Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs, Firm Transmission Rights, FTRs as benefits and liability, FTR auction models. Predicting electricity costs, electricity cost derivation, electricitypricing of inter provincial power market.

Module-IV (8 hours)

Electric energy trading: Trading framework. Derivative instrument for energy trading (forward contracts, futures contracts, swaps), Portfolio management, Energy trading hubs.

Hedging Tools: Definition of risk and hedge. Source of electricity market risks, Value-at-Risk, country party risk, hedging weather risks.

Module-V (7 hours)

Ancillary Services: Classifications and definitions. Types, Frequency control ancillary service, voltage control ancillary service, reserves & AGC services, System security in deregulation.

Different models of deregulation- Indian model, UK model, Californiamodel, Australian and New Zealand models, Japan model, Thailand model. AS management in various markets- country practices. IT applications in restructured markets. Recent trends in Restructuring.

Recommended Books

K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, *"Operation Of Restructured Power System",* Kluwer Academic Publishers, 2001

Mohammad Shahidehpour, MuwaffaqAlomoush, "Restructured electrical power systems: operation, trading and volatility", Marcel Dekker

S. Stott, "Power System Economics: Designing Markets For Electricity", Wiley-Interscience, 2002.

D. S. Kirschen and G. Strbac, *"Fundamentals Of Power System Economics",* John Wiley & Sons, 2004

Course Outcomes:

Upon completion of the course, the students will:

CO1	Define the fundamentals of electricity markets.
CO2	Evaluate different transmission pricing paradigms.
CO3	Incorporate the operation of power systems under transmission congestion.
CO4	Analyze electrical energy trading and hedging concepts.
CO5	Demonstrate about ancillary services and different country practices.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Power System Lab-I

Syllabus:

[1]. Simulation experiments on Modeling of Transmission Lines
[2]. Formation of Bus Admittance Matrix
[3]. Formation of Bus Impendence Matrix
[4]. Load Flow Analysis using Newton-Raphson Method/ Decoupled Method
[5]. Optimal power flow solution
[6]. Fault Analysis-I
[7]. Transient and Small Signal Stability Analysis: Single-Machine Infinite Bus System
[8]. Load – Frequency Dynamics of Single –Area and Two Area Power Systems
[9]. Design of Distance Protection Scheme using PSCAD
[10]. Design of HVDC controller using PSCAD
[11]. Power flow analysis of standard test systems using ETAP & PowerFactory
[12]. Short-circuit analysis of standard test systems using ETAP & PowerFactory

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Build admittance and impedance matrices and simulate power systems
CO2	Perform load flow analysis and optimal power flow analysis.
CO3	Perform fault analysis in power systems.
CO4	Perform transient and small signal stability analysis.
CO5	Design of protection schemes and HVDC controllers using PSCAD.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**3**	**3**	**3**	**3**	**3**

Eight Semester
Power System Dynamics

SYLLABUS

Module-I (7 hours)

Power System Stability Problems: Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.

Module-II (10 hours)

Small Signal Stability: State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, small signal stability of a single machine infinite bus system, Studies of parametric effect: effect of loading, effect of KA, effect of type of load, Hopf bifurcation, Electromechanical oscillating modes, Stability improvement by power system stabilizers. Design of power system stabilizers.

Module-III (10 hours)

Large Perturbation Stability: Transient stability: Time domain simulations and direct stability analysis techniques (extended equal area criterion) Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modeling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multi-machine PEBS.

Module-IV (6 hours)

Sub Synchronous Oscillations: Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters

Module-V (6 hours).

Sub Synchronous Resonance (SSR): characteristics of series capacitor -compensated transmission systems, self – excitation due to induction generator effect, torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems. Voltage stability, System oscillations.

Recommended Books

[1]. P. Kundur, *"Power system stability and control",* McGraw-Hill, 1994

[2]. P. Sauer and M. Pai, *"Power system dynamics and stability",* Prentice Hall, 1998

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate the concept of stability of large power system.
CO2	Analyze small signal stability problems.
CO3	Analyze large signal stability problems.
CO4	Analyze the torsional oscillation problems
CO5	Evaluate the sub-synchronous resonance phenomenon and demonstrate methods to counter this phenomenon.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Reliability of Power Systems

SYLLABUS

MODULE-I (10 HOURS)

Generating Capacity Basic Probability Methods: The generation system model, Loss of load indices, Equivalent forced outage rate, Capacity expansion analysis, Scheduled outages, Evaluation methods on period basis, Load forecast uncertainty, Forced outage rate uncertainty, Loss of energy indices.

MODULE-II (10 HOURS)

Generating Capacity Frequency & Duration Method: The generation model, System risk indices.

Interconnected Systems: Probability error method in two interconnected systems, Equivalent assisting unit approach to two interconnected systems, Factors affecting the emergency assistance available through the interconnections, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected system, multi connected system, Frequency & duration approach.

MODULE-III (10 HOURS)

Operating Reserve: General concepts, PJM method, Extension to PJM method, Modified PJM method, Postponable outages, Security function approach, Response risk, Interconnected systems.

Composite Generation & Transmission Systems: Radial configurations, Conditional probability approach, Network configurations, State selection, System & load point indices, Application to practical systems, Data requirements for composite system reliability.

MODULE-IV (10 HOURS)

Distribution Systems Basic Techniques & Radial Networks: Evaluation techniques, additional interruption indices, Application to radial systems, effect of lateral distributor protection, Effect of disconnects, Effect of protection failures, effect of transferring loads, Probability distributions of reliability indices.

MODULE-V (10 HOURS)

Distribution Systems-Parallel & Meshed Networks: Basic evaluation techniques, Inclusion of bus bar failures, Inclusion of scheduled maintenance, Temporary & transient failures, Inclusion of weather effects, Common modes failures, Common mode failures & weather effects, Inclusion of breaker failures.

Plant & Station Availability: Generating plant availability, Derated states & auxiliary systems, Allocation & effect of spares, Protection systems.

Recommended books

[3]. Billinton Roy& Allan Ronald *"Reliability of Power system",* Pitman Pub. 1984

[4]. Richard Elect. Brown, *"Electric Power Distribution Reliability"*, CRC Press.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Evaluate reliability of generating capacity.
CO2	Evaluate the reliability of interconnected system.
CO3	Evaluate the reliability of operating reserves, composite generation & transmission system.
CO4	Evaluate reliability indices of simple radial distribution network.
CO5	Evaluate the reliability of parallel and meshed network and to study the effect of plant and station availability.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Program Elective-IV

Digital Protection of Power Systems

Module-I (9 hours)

Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection, Expected benefits of digital relaying, Digital relay architecture, Analog to digital converter, Anti-aliasing filter, Substation computer hierarchy.

Module-II (5 hours)

Functions of a protection system, Protection of transmission lines, Transformer Protection, Reactor & generator protection, Digital Bus protection, Performance of current & voltage transformer.

Module-III (10 hours)

Mathematical Basis for Protective Relaying Algorithms: Introduction, Fourier series, Fourier transform, Use of Fourier transform, Discrete Fourier transform, Introduction to probability & random processes, Kalman filtering,

Transmission Line Relaying: Introduction, Sources of error, Symmetrical component distance relay, Protection of series compensated lines, Power transformer algorithm.

Module-IV (5 hours)

Hardware Organization In Integrated Systems: The nature of hardware issues, Computers for relaying, The substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary equipment, Redundancy & backup, Servicing, Training & maintenance.

Module-V (10 hours)

Measurement of frequency & phase, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurement in dynamic state estimation, Developments in New Relaying Principles: Introduction, Traveling waves on single phase lines, Traveling waves on three phase lines, Traveling waves due to faults, Traveling wave distance relays, Directional wave relays, Differential relaying with phasors, Traveling wave differential relays.

Textbooks:

[1]. A.G. Phadke and J.S. Thorp, "*Computer Relaying for Power Systems*", John Wiley and Sons,1994.
[2] A.T. Johns and S. K. Salman, *"Digital Protection of Power Systems"*, IEEE Press,1999

Reference Books:

[1] Stanley H. Horowitz and Arun G. Phadke, "*Power System Relaying*", Research Studies Press Ltd., England. J.L. Blackburn, "*Protective, Relaying*", Marcel Dekker, Inc., 1987.
[2] Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006
[3] S.R. Bhide "Digital Power System Protection" PHI Learning Pvt. Ltd. 2014

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate concept of computer programming relaying and its architecture.
CO2	Analyze different protection schemes of power system.
CO3	Apply mathematical approach towards protection and will learn to develop various protection algorithm.
CO4	Demonstrate the basic requirements of digital protection.
CO5	Analyze different techniques to realize the protective measures over a computer network and fundamentals of phasor measurement unit.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

Course	**3**	**1**	**3**	**3**	**2**	**1**

Wide Area Monitoring and Control

Module-I (5 hours)

INTRODUCTION TO WIDE AREA MEASUREMENT SYSTEM (WAMS): Need of WAMS, Architecture, Components of WAMS, Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, Wide Area Monitoring Protection & Control and Remedial Action Scheme.

Module-II (10 hours)

POWER SYSTEM AUTOMATION: Introduction, Evolution of Automation Systems, Supervisory Control and Data Acquisition (SCADA) Systems, Components of SCADA Systems, SCADA in Power Systems, SCADA Basic Functions,Advantages of SCADA in Power Systems, Deferred Capital Expenditure, Optimized Operation and Maintenance Costs, Equipment Condition Monitoring (ECM), Sequence of Events (SOE) Recording, Power Quality Improvement, Data Warehousing for Power Utilities, Types of Data and Signals in Power Systems, Flow of Data from the Field to the SCADA Control Center.

Module-III (10 hours)

SCADA FUNDAMENTALS: Introduction, Open System: Need and Advantages, Building Blocks of SCADA Systems, Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication Subsystem, Logic Subsystem, Termination Subsystem, Testing and Human Machine Interface (HMI) Subsystem, Power Supplies, Advanced RTU Functionalities, Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED Functional Block Diagram, Hardware and Software Architecture of the IED, IED Communication Subsystem, IED Advanced Functionalities, Tools for Settings, Commissioning, and Testing, Programmable LCD Display, Typical IEDs, Data Concentrators and Merging Units, RTUs, IEDs, and Data Concentrator, Merging Units and IEDs.

Module-IV (5 hours)

SUBSTATION AUTOMATION: Substation Automation: Technical Issues, System Responsibilities, System Architecture, Substation Host Processor, Substation LAN, User Interface, Communications Interfaces, Protocol Considerations. The New Digital Substation, Process Level, Protection and Control Level, Station Bus and Station Level, Substation Automation Architectures, Legacy Substation Automation System, Digital Substation

Automation Design, New versus Existing Substations. Substation Automation (SA) Application Functions, Integrated Protection Functions: Traditional Approach and IED-Based Approach. Automation Functions.

Module-V (10 hours)

VOLTAGE STABILITY & SMALL SIGNAL STABILITY: Basic concepts, Voltage collapse – general characterization, classification, Voltage stability analysis – modeling, dynamic analysis, static analysis, shortest distance to instability, continuation power flow analysis, prevention of voltage collapse – design measures, operating measures, Real time wide area controller for mitigating small signal Instability, Advanced monitoring and control approaches for enhancing power system security.

Textbooks:

[1]. A. R. Messina, '*Wide Area Monitoring of Interconnected Power Systems'* IET, Power& Energy Series, 2005.

[2] Allen J. Wood and Bruce Woolenberg, '*Power System Generation, Operation and Control*', John Wiley and Sons, 1996.

Reference Books:

[1] P. Kundur, '*Power System Stability and Control*', McGraw Hill.

[2] A.R. Messina, '*Inter-area Oscillations in Power Systems*' Springer

[3] D. K. Mohanta & M. Jaya Bharata Reddy, '*Synchronized Phasor Measurements for Smart Grids*' IET, Power & Energy Series.

[4] Mini S. Thomas and John Douglas McDonald, '*Power System SCADA and Smart Grids*',CRC Press, 2015.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define the necessity of wide area measurement system and its basic concept.
CO2	Apply different automation systems.
CO3	Demonstrate the fundamentals of SCADA and its importance in real time power systems.
CO4	Implement substation automation, new digital substation and traditional approach and IED-based approach of integrated protective functions.
CO5	Evaluate voltage stability, prevention of voltage collapse, dynamic stability analysis and small signal stability analysis.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Advanced Digital Signal Processing

Module-I (8 hours)

Discrete time signals, systems and their representations: Discrete time signals (Linear Time Invariant systems, Stability and causality).

Discrete Fourier Transform: Properties of different transforms, Linear convolution using DFT-Computation of DFT.

Module-II (8 hours)

Digital filter design and realization structures: Design of IIR digital filters from analog filters, Impulse invariance method and Bilinear transformation method, FIR filter design using window functions, Comparison of IIR and FIR digital filter, Basic IIR and FIR filter realization structures, Signal flow graph representations.

Module-III (8 hours)

Finite Word-Length Effects on Digital Filter: Analysis of finite word-length effects Quantization process and errors, Coefficient quantization effects in IIR and FIR filters, A/D conversion noise-Arithmetic round-off errors, Dynamic range scaling, Overflow oscillations and zero input limit cycles in IIR filters.

MODULE-IV (7 hours)

Statistical digital signal processing: Linear Signal Models All pole, All zero and Pole-zero models, statistical properties of random signal.

MODULE-V (8 hours)

Power spectrum estimation: Spectral analysis of deterministic signal, Estimation of power spectrum of stationary random signals, Optimum linear Filters, Optimum signal estimation, Mean square error estimation, Optimum FIR and IIR filters.

TEXT BOOKS

[1]. John G. Proakis, and Dimitris G. Manolakis, "Digital Signal Processing" (third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997

[2]. Alan V. Oppenheim, Ronald W. Schafer, "Discrete-Time Signal Processing", Prentice-Hall of India Pvt. Ltd., New Delhi, 1997

REFERENCE BOOKS

[1] A. Nagoor Kani, "Digital Signal Processing", Second edition, Mc Graw Hill.

[2]. Sanjit K Mitra, "A computer-based approach", Tata Mc Grow-Hill edition .1998

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define the basic concept of Digital Signal Processing, Discrete Fourier Transform and its application.
CO2	Analyze digital filter design and its structural realization.
CO3	Demonstrate the errors of word length effect and their correction techniques.
CO4	Apply the knowledge of statistical digital signal processing.
CO5	Compile power spectrum estimation.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Wireless Sensor Networks

Syllabus:

MODULE-I(5 hours)

Limitations of Wired Network Protocols; Benefits of Wireless Network Protocols/ Wireless Sensor Networks (WSNs); Introduction to IEEE 802.xx Standards: specifications of bandwidth, SNR, range of measurement of physical parameters. Communication Networks for industry, home appliances, office automation and biomedical applications.

MODULE-II(10 hours)

Wireless LAN (WLAN): Direct Sequence Spread Spectrum (DSSS) technique, Frequency Hoping Spread Spectrum (FHSS) technique. Wi-Fi (IEEE 802.11); Bluetooth (IEEE 802.15.1), WRAN (IEEE 802.15.1), and Wireless HART (IEEE 802.15.1/ ISA 100.11a); Zigbee (IEEE 802.15.4); WiMAX (IEEE 802.16e); MBWA (IEEE 802.20).

MODULE-III(7 hours)

Advances in WSN: IEEE 1451.5 Standard: IEEE 1451.2 - transducer to microprocessor communication protocol and TEDS (transducer Electronic Data Sheet) formats; IEEE 1451.3 - digital communication and TEDS format for distributed multi-drop system; IEEE 1451.4 - mixed mode communication protocols and TEDS format; IEEE 1451.5 – wireless communication protocols and TEDS formats; IEEE 1451.6: high speed CAN open-band transducer network interface for intrinsically safe and non-intrinsically sate applications; IEEE 1451.7 – transducer to radio frequency identification (RFID) system communication protocols and TEDS formats.

MODULE-IV(9 hours)

Real-life Applications - Sensors interconnection with wireless sensor nodes: Xbee based modules can be used as it is mesh capable; Bluetooth 2.0 enabled hardware. Centralized gateways: Collect data from various sensor nodes; Pre-processing of data; Sending data to the cloud for further processing. Mesh compatible protocols: communicate over long distance; Consume low power, MQTT protocol, IPv6, Zigbee (IEEE 802.15.4), Bluetooth.

MODULE-V(9 hours)

Optimization of sensor networks using IoT enabled sensors: Sensor Placement Optimization; Coverage and connectivity; Energy Consumption optimization, and Fault Tolerance. IoT System architecture: Physical Layer - Sensor and actuators with embedded processing units; Communication Layer, and Application Layer; Enabling IEEE 1451.5 protocol with IoT.

Books:

1. Christian Poellabauer and Waltenegus Dargie, Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley, 2010.
2. Kazem Sohraby, Wireless Sensor Networks, Springer, edited by Taieb Znati, 2005.

Reference books:

1. Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005.

Course Outcomes:

CO1	Demonstrate the limitations of wired network protocols, benefits of wireless network protocols/ wireless sensor networks (WSNs), and their applications.
CO2	Define the existing WSN schemes and standards.
CO3	Incorporate WSN technology with TEDS.
CO4	Plan sensors interconnection with wireless sensor nodes and further developments in this direction.
CO5	Evaluate the advances in WSNs technologies and use of optimized sensor networks and IoT enabled sensors.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Program Elective-V

FACTS and Custom Power Devices

Module-I (8 hours)

FACTS concepts and general system considerations: Power flow in AC system, transient stability and dynamic stability, basic description of FACTS controllers, brief review of voltage sourced converter and current sourced converter, modelling philosophy.

Module-II (8hours)

Static VAR compensator (SVC and STATCOM): objectives of shunt compensation, methods of controllable VAR Generation, regulation slope, transfer function, V-I and V-Q characteristics, transient stability enhancement, VAR reserve control, conventional power flow models, shunt variable susceptance model, firing angle model, transient stability model, voltage magnitude control using SVC & STACOM, Application example.

Module-III (8 hours)

Static Series compensators (TCSC and SSSC): objectives of series compensation, improvements of voltage and transient stability, power oscillation damping, sub-synchronous damping, transmittable power and transmittable angle characteristics, control range, conventional power flow models, variable series impedance model, firing angle model, transient stability model, active power flow control using TCSC & SSSC, Application example.

Module-IV: (8 hours)

Static voltage and phase angle regulator (TCVR and TCPAR): objectives of voltage and phase angle regulators, approaches to TCVR and TCPAR, switching converter based voltage and phase angle regulators, Unified power flow controller: Basic operating principles, transmission control, independent real and reactive power flow control, power flow models, transient stability model, control structure, basic control system for P and Q control, dynamic performance, Application example.

Module-V (7 hours)

Brief control studies such as Steady state analysis and control, EMTP studies, power oscillation stability analysis and control, transient stability control.

Recommended Books

1. Y. H. Songs, A. T. Johns, “Flexible AC Transmission Systems”, IEE Press, 1999
2. N. G. Hingorani, L. Gyugyi, “Understanding FACTS”, IEEE Press, Indian Edition, 2001.
3. E. Acha, “FACTS: Modelling And Simulation In Power Networks”, John Wiley & Sons, 2004.
4. K. R. Padiyar ,”FACTS Controllers in Power Transmission & Distribution”, New Age International Publishers.
5. Vijay K. Sood , “HVDC and FACTS Controller: Applications of Static Converters in Power Systems” , Kluwer Power Electronics & Power System Series , 2006.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define basic philosophy of FACTS devices and modeling and control aspect of FACTS devices.
CO2	Analyze fundamental function of SVC and STATCOM.
CO3	Analyze power system operation with TCSC and SSSC.
CO4	Demonstrate power flow control using TCVR, TCPAR and UPFC.
CO5	Evaluate the comprehensive control of power system using FACTS devices.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Power Electronic Converters

Module-I (8 hours)

Power Electronic Devices: Diodes, Transistors, Thyristors, MOSFET and IGBT - operating principle, Static, dynamic and thermal characteristics, Data sheet ratings, gate drive circuits.

Module-II(8hours)

Single phase half controlled and fully controlled AC/DC bridge converter with R, R-L, R-L-E (motor) loads: operation (both rectifier and inverter modes) , waveforms ,harmonics (output voltage/current and input current) assuming continuous conduction, input current (ac) displacement, distortion and power factor, effect of input line inductance assuming constant current dc load, closed form expression of output dc current with general R-L-E load, discontinuous conduction mode of operation.

Module-III (8 hours)

Three phase half controlled and fully controlled AC/DC bridge converter assuming constant dc current load : operation in rectifier and inverter modes, waveforms, output voltage and input current harmonics, input power factor and effect of input line inductance, series and parallel operation of converters, power factor improvement, 12 pulse/18 pulse operation, transformer connection, dual converters.

Module-IV: (8 hours)

DC-DC choppers: basic voltage commutated thyristor chopper analysis , Separately excited DC motor drive using DC-DC choppers made of gate controlled devices, four quadrant operation, dynamic and regenerative braking of series DC motor using choppers; Basic DC-DC converters: buck, boost buck-boost and Cuk converter, operation, waveforms.

Module-V(7 hours)

DC-AC inverters using gate controlled devices: single phase and three phase square wave inverters, operation waveforms and harmonics in pole voltage, load phase voltage and line voltage, output voltage control in single phase square wave inverter using chopper control and phase shift, harmonic analysis, operating principles of single phase and three phase PWM inverters, modulation techniques, SPWM, Selective Harmonic Elimination PWM and delta modulation, harmonic spectrum and comparison among different PWM techniques. Variable frequency operation of three phase induction motors: Steady state analysis, Torque-speed, current, speed and slip frequency -speed characteristics and operating limits with constant volts/Hz and constant air gap flux operation, implementation using PWM VSI.

Text Books

1. N. Mohan, T.M. Undeland& W.P. Robbins, *Power Electronics: Converter, Applications & Design*, John Wiley & Sons , New York, 2003.
2. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House , 2002

Reference Books:

1. M.H. Rashid, *Power Electronics, Circuits, Devices, and Applications*, Pearson , 2003
2. B. K. Bose, *Modern Power Electronics and A.C. Drives*, PHI , 2002

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate principle, characteristics rating of various power electronic devices such as transistor, MOSFET, IGBT etc.
CO2	Analyze single phase AC/DC bridge converter operation, output and input (voltage and current) waveforms.
CO3	Analyze three phase AC/DC bridge converter operation, output and input (voltage and current) waveforms.
CO4	Analyze basic DC-DC converter: buck, boost, buck-boost and Cuk converter, operations and waveforms.
CO5	Analyze DC-AC inverters, its operation and waveforms.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**1**	**3**	**3**	**2**	**1**

Industrial Automation and Control

Syllabus:

MODULE-I

Introduction to process dynamics, its type and classifications. Control actions and controller tuning: Basic control actions-on/off, P, P+I, P+I+D, floating control, pneumatic and electronic controllers, pneumatic vs hydraulic control, controller tuning.

MODULE-II

Introduction to PLC, PAC, DCS and SCADA. IEDs, RTUs, HMI, Smart Sensors and Actuators. IEEE 802.11 / 15 Standards, IEEE 1451.5 Std. Communication Networks for PLC. The Instrument Lists of PLC and HMI. Sequential and Programmable controllers, System Architecture, Programming languages of PLC, Relay logic and Ladder logic, Ladder Diagram Elements.

MODULE-III

Computer controlled processes: PLC based control of different types of processes such as liquid level system and flow control, open-and-closed chamber pressure control, temperature control, different types of heat exchangers, control of pressurized gases.

MODULE-IV

Physical Ladder Diagram and Programmable Ladder Diagram. Different Modules of the System Architecture of PLC. Case Studies: frost free refrigerator / freezer system; composite discrete / continuous control; conveyor system; oven system; elevator system; uniformly heated liquid control system, and hydro-phonic system.

MODULE-V

Advances in Automation: Programmable Automation Controllers. NI my-DAQ, my-RIO, c-RIO, and ELVIS. Role of Internet of Things and Cyber Physical System in Industry Automation, MQTT protocol.

Books:

1. Peter D. Harriot, “Process Control”, Tata McGraw-Hill, New Delhi, 2009.
2. Liptak, “Process Control: Instruments Engineer’s Handbook”, Butterwirth Heinemann, 1995.

3. Curtis D. Johnson, "Process Control and Industrial Technology", Pearson India, 8th ed., 2012.

Reference books:

1. Norman A Anderson, Instrumentation for Process Measurement and Control, CRC Press, 2008.
2. B. Wayne Bequette, "Process Control – Modeling, Design, and Simulation", Pearson India, 2015.
3. John W. Webbs, "Programmable Logic Controllers – Principals and Applications", fifth Edition, Pearson India /PHI (Old edition), 2012.

Course Outcomes:

CO1	Describe the basic principles and importance of process control applications using automation;
CO2	Express the required instrumentation, knowledge of the P&ID, the Instrumentation Lists, and final elements to ensure that well-tuned control is achieved;
CO3	Create computer control mechanism of various processes
CO4	Design, install, operate, control and maintain different process and automated applications using PLCs/PACs. Further, PLC / PAC algorithm using Ladder Logic Diagram or equivalent languages while handling a plant process;
CO5	Apply knowledge on advances in use of automation platform such as PACs and IoT while handling a plant process.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Industrial Load Modelling and Control

UNIT I MODELING OF PHASE CONTROL OF DC DRIVES (10)

Motor-drives, load torque-speed characteristics, power devices and switches, modeling of DC motor-load- block diagram and transfer function for armature and field control, phase controlled dc motor drives-single phase and three phase controlled converters, control circuit, current source with three phase controlled converter, four quadrant operation, steady state analysis of three phase converter, speed control of two quadrant dc motor drives.

UNIT II CHOPPER CONTROL OF DC MOTOR DRIVES (8)

Principle of operation of the chopper, Steady-state analysis of Chopper-controlled dc motor drive, Continuous Current Conduction, Discontinuous Current Conduction, Closed-loop operation, Pulse-Width-Modulated Current Controller, Hysteresis-Current Controller, dynamic analysis of the speed-controlled dc motor drive.

UNIT III CONTROL OF INDUCTION MOTOR DRIVES (10)

Steady state performance equations of the induction motor, dynamic modeling of induction machines,phase-controlled induction-motor drives- stator voltage control, Closed-Loop Operation, Closed loop control of slip-energy recovery scheme, Pulsating torque, Static Scherbius Drive, frequency-controlled induction motor drives, VSI and CSI fed V/f and PWM control scheme of induction motor drive system.

UNIT IV CONTROL OF SYNCRONOUS AND BLDC MOTOR DRIVES (8)

True mode and Self-control of synchronous motor–Torque control, Power factor control–Brushless excitation systems, Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlled Brushless dc motor drive.

UNIT V: VECTOR CONTROL OF INDUCTION MOTOR DRIVE (10)

Principle of vector control of IM - Direct vector control – Indirect vector control with feedback - Indirect vector control with feed-forward - Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation – Direct Torque Control of IM.

Reference Books

1. R.Krishnan,, Electric Motor Drives - Modeling, Analysis and Control Prentice- Hall of India Pvt. Ltd., New Delhi, 2003.
2. Dubey, G.K, Power semiconductor controlled devices, Prentice Hall International New jersey, 1989.
3. Ned Mohan, "Power Electronics and drives", Wiley 2006Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Pte. Ltd., New Delhi.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate closed loop control of DC motor-load drives using phase control.
CO2	Demonstrate closed loop control of DC motor-load drives using DC-DC chopper control.
CO3	Demonstrate closed loop control of Induction motor drives using phase control.
CO4	Analyze operation of Synchronous motor and BLDC machines, torque control using current and flux controllers.
CO5	Analyze direct and indirect vector control on induction motors.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	**3**	**1**	**3**	**3**	**2**	**1**

Power System Lab-II

Syllabus:

[1]. Economic Load Dispatch by traditional optimization methods using MATLAB

[2]. Study of Unit Commitment Problem using MATLAB

[3]. Study of Load Forecasting by conventional and soft computing methods using MATLAB

[4]. Fault Analysis-II using MATLAB

[5]. Simulation of Power System under Different Conditions

[6]. Transient Stability Analysis of Multi machine Power Systems using SIMULINK

[7]. Load – Frequency Dynamics of Multi- Area Power Systems using SIMULINK

[8]. Simulation of Fuzzy Interfacing Power System using SIMULINK

[9]. Distribution Transformer Steep Front Analysis using PSCAD

[10]. Study of Static Var Compensator Connected to an Infinite Bus using PSCAD

[11]. Development of Microgrid Model in DigSilent Power Factory

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Perform economic load dispatch.
CO2	Perform load forecasting using different techniques.
CO3	Perform detailed fault analysis using MATLAB.
CO4	Demonstrate power system simulation using SIMULINK.
CO5	Express emerging power system problems and develop solutions using PSCAD and DigSilent Power Factory.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Course	**3**	**3**	**3**	**3**	**3**	**3**

Minor Project and Seminar

Course description:

As a part of the curriculum, this is a sessional course, in which the students are trained in basic tools and presentation skills.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Identify and analyze engineering problems and research problem.
CO2	Utilize technical resources for problem solving.
CO3	Develop skills to use modern engineering tools, software and equipment.
CO4	Write technical reports and demonstrate the findings in terms of oral presentations.
CO5	Develop confidence and plan for future work.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	**3**	**3**	**3**	**3**	**3**	**3**

Ninth Semester

Program Elective-V

Power System Optimization

SYLLABUS

Module-I (8 hours)

Classical optimization techniques: General formulation of unconstrained and constrained optimization problems. Classical Method of solution. Karush-Kuhn-Tucker (KKT) conditions. Overview of Linear programming, non-linear programming, Quadratic programming and mixed-integer linear programming, and dynamic programming problems.

Module-II (8 hours)

Modern optimization techniques: Concept of heuristic and meta-heuristic methods, Derivative free optimization, Genetic algorithms, neural networks, swarm optimization techniques. Stochastic optimization, application of joint distribution and copula.

Multiobjective optimization: pareto-optimality, selection using fuzzy membership, weighting method, utility function method, global criterion method, goal programming method. Application of evolutionary and swarm optimization approaches.

Module-III (8 hours)

Real power optimization: Lagrange's method of solution of economic dispatch and hydrothermal scheduling problems. Iterative technique. Gradient method. Loss sensitivity calculation. Calculation of constrained shift sensitivity factors. Perturbation method for sensitivity analysis. Voltage sensitivity analysis.Application of evolutionary and swarm optimization techniques. Application of Analytical Hierarchy process for unit commitment.

Module-IV (8 hours)

Reactive Power Optimization: Classical method, linear programming method, Interior point method. VAR optimization by evolutionary algorithm and PSO. Optimal Load Shedding: conventional and intelligent load shedding. Formulation with and without network constraints.

Module-V (7 hours)

Optimization of power system control: formulation of objective function and solution of frequency and voltage control problems. parameter tuning of different controllers using classical and modern techniques.

Recommended Books

1. Jizhong Zhu, Optimization of Power System Operation, Wiley. 2009.
2. James A Momoh, “Electric Power System Application of Optimization”, CRC Press.
2. Engineering optimization by S. S. Rao.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Develop an optimization problem and use classical solution techniques.
CO2	Demonstrate modern optimization techniques.
CO3	Solve real power optimization problems.
CO4	Solve reactive power optimization problems.
CO5	Solve real and reactive power control optimization problems.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Smart Power Grids

Module-I (6 hours)

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid, Present development & International policies in Smart Grid.

Module-II (8hours)

Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.

Module-III (7 hours)

Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

Module-IV (10 hours)

Concept of micro-grid, need & applications of micro-grid, Formation of micro-grid, Issues of interconnection, Integration of renewable energy sources, Protection & control of micro-grid. Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Module-V (7 hours)

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid, Broadband over Power line (BPL), IP based protocols.

References:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "*Smart Grid: Technology and Applications*", Wiley 2012.

2. Clark W. Gellings, "*The Smart Grid: Enabling Energy Efficiency and Demand Response*", CRC Press, 2009.

3. Ali Keyhani, "*Design of smart power grid renewable energy systems*", Wiley-IEEE, 2011.

4. Stuart Borlas'e, "*Smart Grid: Infrastructure, Technology and solutions*", CRC Press.

5. A.G.Phadke, "*Synchronized Phasor Measurement and their Applications*", Springer.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Demonstrate the difference between smart grid & conventional grid.
CO2	Apply smart metering concepts to industrial and commercial installations.
CO3	Formulate solutions in the areas of smart substations, distributed generation and wide area measurements& PMUs.
CO4	Analyze problems associated with integration of distributed generations& come up with their solutions through smart grid.
CO5	Express smart grid solutions using AMI and modern communication technologies.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Forecasting Methods in Power Systems

Module-I (8 hours)

Introduction to data analytics and Python fundamentals. Basics of R programming.

Introduction to probability, Sampling and sampling distributions, Hypothesis testing, Two sample testing and introduction to ANOVA.

Module-II (8 hours)

Nature of time series data, time series statistical models, measures of dependence, stationary time series, estimation of correlation. Classical regression, exploratory data analysis, smoothing, Linear regression and multiple regression, Concepts of MLE and Logistic regression, ROC and Regression Analysis Model Building.

Module-III (8 hours)

Spectral Analysis and Filtering: Cyclical behavior and periodicity. Spectral Density. Periodogram and Discrete Fourier Transform, Nonparametric and parametric spectral estimation, Multiple series and cross-spectra. Linear filters. Lagged regression models. Signal extraction and Optimal filtering. Rprograms.

Module-IV (8 hours)

ARIMA Models: Autoregressive Moving Average Models, difference equations, autocorrelation and partial autocorrelation. Forecasting, estimation.

Long memory ARMA and fractional differencing, Unit Root testing, GARCH models. Threshold models. Lagged regression and transfer function modelling.

Module-V (8 hours)

State Space Models: Linear Gaussian model. Filtering, smoothing and forecasting. Maximum Likelihood estimation, Signal extraction and Forecasting,

Frequency Domain Models: Spectral Matrices and Likelihood functions, Regression for jointly stationary series and with deterministic inputs, Discriminant and Cluster Analysis.

Books

1. Robert H. Shumway, David S. Stoffer. “Time Series Analysis and its Applications”, Fourth Edition.,Springer.
2. Jonathan D. Cryer, Kung-Sik Chan. “Time Series Analysis”, Second Edition, Springer.
3. Larry Wasserman, “All of Statistics”, Springer.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Perform basic R and Python programming for data analytics.
CO2	Perform exploratory data analysis.
CO3	Perform spectral analysis and filtering of power system data.
CO4	Build ARIMA, GARCH and ARMAX models.
CO5	Analyze state space and frequency domain models.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Nonlinear Dynamics

Module-I (8 hours)

One dimensional flows: Flows on the line, fixed points and stability, Linear stability analysis, existence and uniqueness, Potentials. Bifurcations: Saddle-node, Transcritical, Pitchfork bifurcations, Imperfect bifurcations and catastrophe. Flows on the circle.

Module-II (8 hours)

Two dimensional flows: Linear systems, classification. Phase plane: phase portraits. existence, uniqueness and topological consequence, Fixed points and linearlization. Conservative and reversible systems. Index theory.

Module-III (8 hours)

Limit cycles: Introduction, examples, Ruling out closed orbits. Poincare-Bendixson theorem, Lienard systems, Relaxation oscillators, Weakly non-linear oscillators.

Bifurcations: Saddle-node, Transcritical and Pitchfork bifurcations in two dimensions. Hopf bifurcations. Global bifurcations of cycles. Quasiperiodicity.

Module-IV (8 hours)

Lorentz equations: Introduction, a chaotic waterwheel, simple properties, chaos on a strange attractor, Lorentz map, exploring parameter space.

One dimensional maps: Introduction, fixed points and cobwebs, Logistic map, Periodic windows, Liapunov exponent, Universalit and experiments.

Module-V (7 hours)

Fractals: countable and uncountable sets, Cantor set, Dimension of self-similar fractals, Box dimension, Pointwise and correlation dimensions.

Strange Attractors: Introduction, Henon Map, Rossler systems, Attractor reconstruction

Recommended Books

[1]. Steven H. Strogatz, Nonlinear Dyanmics and Chaos, Levant publications.

[2]. M Vidyasagar, "Nonlinear Systems Analysis", Prentice Hall.

[3]. R Seydel, "Practical Bifurcation and Stability Analysis", Springer Verlag.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Define one dimensional flow on the line and circle.
CO2	Analyze two dimensional flows of linear systems and phase plane.
CO3	Analyze limit cycles and bifurcations in two dimensions.
CO4	Analyze Lorentz equations and one-dimensional maps.
CO5	Demonstrate fractals and strange attractors.

Course Articulation Matrix

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

Dissertation (Phase-I)

Course description:

As a part of the M.Tech PSE curriculum, this is a sessional course, in which the students of are trained to perform literature review and formulation of a research problem.

Upon completion of the course, the students will demonstrate the ability to:

CO1	Evaluate published literature and express the research gaps.
CO2	Construct a research problem.
CO3	Compile modern engineering tools, software and equipment and develop research methodology.
CO4	Write technical documents and give oral presentations related to the work completed.
CO5	Develop confidence for self education and ability for life-long learning.

Course Articulation Matrix

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	3	3	3

Dissertation (Phase-II)

Course description:

As a part of the M.Tech PSE curriculum, this is a sessional course, in which the students are trained to analyze a research problem and develop the solution.

Course Outcomes:

Upon completion of the course, the students will demonstrate the ability to:

CO1	Apply selected solution methodology to produce solutions to the chosen problem.
CO2	Analyze the output and demonstrate its validity.
CO3	Organize the results and compile the conclusions.
CO4	Write technical report and express the findings in oral presentations.
CO5	Develop confidence for identifying future scope and ability for life-long learning.

Course Articulation Matrix

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

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	3	3	3