CURRICULUM & SYLLABI

B.Tech. Electrical and Electronics Engineering

Effective from AY: 2024-25 (Revised)

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

HANUMAKONDA, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
Electrical Engineering

VISION

To excel in education, research and technological services in electrical engineering in tune with societal aspirations.

MISSION

- Impart quality education to produce globally competent electrical engineers capable of extending technological services.
- Engage in research & development in cutting edge and sustainable technologies.
- Nurture scientific temperament, professional ethics and industrial collaboration.

Program: B.Tech. Electrical and Electronics Engineering

Program Educational Objectives

PEO-1	Design, develop, innovative products and services in the field of electrical and electronics engineering.
PEO-2	Apply the knowledge of electrical and electronics engineering to solve problems of social relevance,
PEO-3	Work effectively as individuals and as a team in multidisciplinary projects.
PEO-4	Engage in lifelong learning, pursue higher education and research, career enhancement and adapt to changing professional needs.

Program Articulation Matrix

PEO / Mission Statements	**PEO-1**	**PEO-2**	**PEO-3**	**PEO-4**
Impart quality education to produce globally competent electrical engineers capable of extending technological services.	3	3	2	2
Engage in research & development in cutting edge and sustainable technologies.	1	2	1	3
Nurture scientific temperament, professional ethics and industrial collaboration.	3	3	2	2

1 - Slightly **2 - Moderately** **3 - Substantially**

Program: B.Tech. Electrical and Electronics Engineering

Program Outcomes

PO-1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, Engineering fundamentals, and Electrical Engineering to the solution of complex engineering problems.
PO-2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with consideration for sustainable development.
PO-3	**Design/Development of Solutions:** Design solutions for complex Electrical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon, cultural, societal, and environmental considerations.
PO-4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, modelling, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	**Engineering Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex electrical engineering activities with an understanding of the limitations.
PO-6	**The Engineer and the World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
PO-7	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion, and adhere to national and international laws in engineering practice.
PO-8	**Individual and Collaborative Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in diverse/multidisciplinary settings.
PO-9	**Communication:** Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-10	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-11	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change.

Program Specific Outcomes

PSO-1	Analyse, synthesize and design electrical and electronic equipment and systems to enhance the quality of human life.
PSO-2	Develop innovative and environment–conscious electrical and electronic technologies to sustain human life.

CURRICULUM
B.Tech. Electrical and Electronics Engineering

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	EE1101	Electric and Magnetic Fields	3-0-0	3
4	CS1101	Programming and Data Structures	3-0-0	3
5	BT1161	Biology for Engineers	2-0-0	2
6	CS1103	Programming and Data Structures Lab	0-1-2	2
7	IC1101	EAA – I (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**17**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1162	Integral Calculus, Vector Calculus and Laplace Transforms	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	CE1164	Basic Engineering Mechanics	3-0-0	3
5	EE1102	Design Thinking	0-1-4	3
6	EE1104	Electrical Circuits – I	3-0-0	3
7	ME1165	Engineering Workshop Practice	0-1-2	2
8	IC1102	EAA – II (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**21**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1261	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3
2	EE1201	Electrical Circuits – II	3-0-0	3
3	EE1203	Electrical Machines – I	3-0-0	3
4	EE1209	Electrical Measurements & Instrumentation	3-0-2	4
5	EC1261	Analog Electronics	3-0-0	3
6	EC1265	Analog Electronics Lab	0-1-2	2
		Total Credits		**18**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE1202	Electrical Machines – II	3-0-0	3
2	EE1206	Control Systems	3-0-0	3
3	EE1212	Artificial Intelligence and Machine Learning	2–0–2	3
4	EE1214	Power Systems – I	3-0-0	3
5	EC1262	Switching Theory and Logic Design	3-0-0	3
6	EE1216	Electrical Circuits Lab	0-1-2	2
7	EC1264	IC Applications Lab	0-1-2	2
		Total Credits		**19**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE1301	Power Electronics	3-0-0	3
2	EE1303	Microprocessors & Microcontrollers	3-0-2	4
3	EE1313	Power Systems – II	3-0-0	3
4	EE1315	Digital Signal Processing	3-0-0	3
5	MS1369	Principles and Practices of Management for Electrical Engineers	3-0-0	3
6	EE1309	Control Systems Lab	0-1-2	2
7	EE1311	Electrical Machines Lab	0-1-2	2
8	EE1381	Fractal Course – I	1-0-0	1
		Total Credits		**21**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE1312	Electric Drives	3-0-0	3
2	EE1314	Power System Operation & Control	3-0-0	3
3	EE13XX	Program Elective – I	3-0-0	3
4	EE13XX	Program Elective – II	3-0-0	3
5	EE1306	Product Development	0-1-4	3
6	EE1310	Electrical Simulation Lab	0-1-2	2
7	EE1316	Digital Signal Processing Lab	0-1-2	2
8	EE1382	Fractal Course – II	1-0-0	1
		Total Credits		**20**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE1407	Power System Protection	3-0-0	3
2	EE14XX	Program Elective – III	3-0-0	3
3	EE14XX	Program Elective – IV	3-0-0	3
4	EE14XX	Open Elective	2-0-0	2
5	EE1403	Power Electronics & Drives Lab	0-1-2	2
6	EE1409	Power Systems Lab	0-1-2	2
7	EE1489	Seminar & Technical Writing	0-0-0	2
8	EE1491	Short Term Industrial / EPICS / Research Experience	0-0-0	2
9	EE1495	Minor Project	0-0-0	2
		Total Credits		**21**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE14XX	Program Elective – V	3-0-0	3
2	EE14XX	Program Elective – VI	3-0-0	3
3	EE14XX	Program Elective – VII	3-0-0	3
4	EE1498	Major Project	0-0-0	6
		Total Credits		**15**

Program Elective Courses

Program Elective – I & II		
S.No.	**Code**	**Course Title**
1	EE1322	Design of Electrical Systems
2	EE1324	AI Techniques in Electrical Engineering
3	EE1326	Computer Methods in Power Systems
4	EE1328	High Voltage Engineering
5	EE1330	Modelling & Analysis of Electrical Machines
6	EE1332	Electrical Vehicle Battery Management System
7	EE1334	Utilization of Electrical Energy
8	EE1336	Industrial Instrumentation and Automation
9	EE1338	IoT in Electrical Engineering
10	EE1340	Special Machines
11	EE1342	Python Programming
12	EE1344	Energy System Analytics
13	EC1364	Synthesis of Digital Systems

Program Elective – III & IV		
S.No.	**Code**	**Course Title**
1	EE1421	Switched Mode Power Conversion
2	EE1423	Planning an Entrepreneurial Venture
3	EE1425	Illumination Engineering
4	EE1427	Power Quality
5	EE1429	Quantum Computing Techniques in Electrical Engineering
6	EE16025	Electric Vehicles
7	EE36021	Restructured Power Systems
8	EE46001	Linear Control System

Program Elective – V, VI & VII		
S.No.	**Code**	**Course Title**
1	EE1422	HVDC & FACTS
2	EE1424	Smart Grid Technologies
3	EE1426	Advanced Electrical Drive Systems
4	EE1428	State Space Approach to Control Systems
5	EC1462	VLSI
6	EE16026	Control and Integration of Renewable Energy Sources
7	EE16034	Advanced Control Techniques for Power Converters
8	EE26022	Real-Time Control of Power Systems
9	EE26024	Distribution System Planning and Automation
10	EE26030	Evolutionary Algorithms Applications in Power Engineering

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	CY1161	Engineering Chemistry	3-0-2	4
4	MA1162	Integral Calculus, Vector Calculus and Laplace Transforms	3-0-0	3
5	MA1261	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	BT1161	Biology for Engineers	2-0-0	2
2	CS1101	Programming and Data Structures	3-0-0	3
3	CS1103	Programming and Data Structures Lab	0-1-2	2
4	CE1164	Basic Engineering Mechanics	3-0-0	3
5	ME1165	Engineering Workshop Practice	0-1-2	2

Humanities and Social Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	HS1161	English for Technical Communication	2-0-2	3
2	MS1369	Principles and Practices of Management for Electrical Engineers	3-0-0	3
3	IC1101	EAA – I	--	0
4	IC1102	EAA – II	--	0

The Overall Credit Structure

Course Category	Credits
Basic Science	17
Engineering Science	12
Humanities and Social Sciences	6
Program Core	94
Program Elective	21
Open Elective	2
Total Graded Credit Requirement	152

Minor in Electrical Engineering

S.No.	Code	Course Title	L-T-P	Credits
1	EE1M01	Electrical Measurement Techniques	3-0-0	3
2	EE1M02	Elements of Electrical Power Systems	3-0-0	3
3	EE1M03	Power Converters and Applications	3-0-0	3
4	EE1M04	Industrial Applications of Electrical Energy	3-0-0	3
5	EE1M05	Elements of Smart Grid Systems	3-0-0	3
			Total Credits	**15**

Honors in Electrical & Electronics Engineering:

S.No.	Code	Course Title	L-T-P	Credits
1	EE16028	High Power Inverters	3-0-0	3
2	EE46024	Digital Control Systems	3-0-0	3
3	EE16027	Power Quality Improvement Techniques	3-0-0	3
4	EE26001	Advanced Computational Methods in Power Systems	3-0-0	3
5	EE26002	Digital Protection of Power Systems	3-0-0	3
			Total Credits	**15**

DETAILED SYLLABI

B.Tech. Electrical and Electronics Engineering

1st Semester

MA1161 **3-0-0 (3)**

Linear Algebra, Calculus and Ordinary Differential Equations

Pre-requisites: None

Course Outcomes:

CO-1	Solve the consistent system of linear equations
CO-2	Apply orthogonal transformations to a quadratic form
CO-3	Determine the series expansion of a given function
CO-4	Explore the properties of functions of several variables
CO-5	Solve arbitrary order linear differential equations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-2	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-3	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-4	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-5	3	3	1	2	1	–	–	–	–	–	–	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Linear Algebra: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions;Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima andminima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

Learning Resources:

Text Books:

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, 11th Edition.
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, 9th Edition.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition.

Reference Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition.
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition.

PH1161 **3-0-2 (4)**

Engineering Physics

Pre-requisites: None

Course Outcomes:

CO-1	Solve engineering problems using the concepts of Interference, diffraction and polarization.
CO-2	Assess the technological applications of lasers and optical fibers.
CO-3	Apply the quantum mechanical principles for solving engineering problems.
CO-4	Analyze the properties of nanomaterials and their engineering applications.
CO-5	Demonstrate the production, detection and applications of ultrasonics.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	2	-	-	-	-	-	-	-	3	2
CO-2	3	3	2	2	-	-	-	-	-	-	-	3	2
CO-3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO-4	3	3	2	2	-	-	-	-	-	-	-	3	2
CO-5	3	3	2	2	-	-	-	-	-	-	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Interference: Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

Diffraction: Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

Polarization: Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

Lasers & Optical Fibers: Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, Heisenberg uncertainty principle, Schrodinger time independent and time

dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunnelling and applications.

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials.

Ultrasonics: Production, detection, and applications of ultrasonics.

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit
11. Strain Gauge
12. Dielectric constant measurements
13. Determination of carrier concentration, charge by using Hall effect experiment
14. Study of I-V characteristics of Solar Cell
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

Learning Resources:

Text Books:

1. Resnic and Walker, Fundamentals of Physics by Halliday, John Wiley, 2011, 9th Edition.
2. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics. McGraw Hill Publications, 2009, 6th Edition.
3. Engineering Physics by Shatendra Sharma, Jyotnsa Sharma, Pearson Education,2018.
4. Nanotechnology: principles and practices by Sulabha K. Kulkarnl. Springer publications, 2018, 3rd Edition.
5. Practical Physics by G.L. Squire, Cambridge University press, 2001, 4th Edition.

Reference Books:

1. Optics by Ajoy K. Ghatak, Tata McGraw Hill, 2017, 6th Edition.
2. Jeff Hecht, Understanding Lasers An Entry-Level Guide, Wiley Publications, 2018, 4th Edition.
3. M.N. Avadhanulu, P.G. Khirsagar, A Textbook of Engineering Physics, 2011, 9th Edition.
4. Hugh D. Young, Roger A. Freedman, University Physics with modern physics, Pearson Education, 2014.
5. B. Rogers, J Adams and S. Pennathur, Nanotechnology the whole story, CRC Press. 2013.
6. Dr. S.K. Gupta, Engineering Physics Practical, Krishna Prakashan Publications, 2010, 9th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/107/122107035/

EE1101 **3-0-0 (3)**

Electric and Magnetic Fields

Pre-Requisites: None

Course Outcomes:

CO-1	Compute electric fields, magnetic fields and associated forces for symmetric charge and current distributions.
CO-2	Calculate capacitance and inductance of common conductor configurations and the energy stored in them.
CO-3	Analyze time-varying electromagnetic fields and stored field energy using Maxwell's equations.
CO-4	Evaluate electromechanical energy conversion based on field energy and co-energy concepts.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	1	2	1	1	1	1	1	3	3	2
CO-2	3	3	1	1	2	1	1	1	1	1	3	3	2
CO-3	3	3	1	1	2	2	1	1	1	1	3	3	2
CO-4	3	2	1	1	2	1	1	1	1	1	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Overview of Coordinate System and Vector Calculus: Scalar and vector fields, overview of coordinate system, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Review of the concepts of gradient, divergence and curl.

Electrostatics: Electrical and magnetic Fields in electrical apparatus, Coulomb's law, Electrical filed intensity, electric flux density, electric field due to point, line, sheet, spherical charge distributions, Gauss' law and its applications, Divergence and curl of electrostatic field, Energy expended in moving a charge in an electric field, electric potential, potential due to point, line, spherical charge distributions, potential gradient, Poisson's and Laplace' equations, Uniqueness theorem, Electric dipole, Dipole moment, potential and electric field due to an electric dipole, Torque on an Electric dipole in an electric field, resistance, capacitance, Dielectrics, Energy in electrostatic field, boundary conditions.

Magnetostatics : Biot-Savart's law, magnetic flux density, magnetic field intensity, magnetic field due to straight wire, surface, solenoid, toroid carrying steady current Ampere's Law and its applications, Divergence and curl of Magnetic field, Comparison of magnetostatics and electrostatics, Magnetic scalar and vector potentials, Lorentz force, inductance, self and mutual inductance of solenoid, toroidal and other simple configurations, conductors, magnetic materials, Hall effect, energy in magneto static fields, boundary conditions.

Time Varying Fields: Equation of continuity, Faraday's law, Lenz's law, transformer emf and motional emf, inconsistency of Ampere's law, displacement current, electromagnetic waves and Maxwell's equations, Poynting theorem, energy in electro-magnetic fields.

Learning Resources:

Text Books:

1. William H. Hayt Jr., John A. Buck, and M Jaleel Akhtar, Engineering Electromagnetics, McGraw Hill, 2020, 9th Edition.
2. David J.Griffiths, Introduction to Electrodynamics, Pearson Education, 2013, 4th Edition.
3. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, and Steven D. Pekarek, Analysis of Electric Machinery & Drive systems, Wiley-IEEE Press, 2013, 3rd Edition.

Reference Books:

1. Matthew Sadiku and S.V. Kulkarni, Elements of Electromagnetics, Oxford University Press, 2015, 6th Edition.
2. Nathan Ida, Engineering Electromagnetics, Springer, 2021, 4th Edition.
3. A.E Fitzgerald, C. Kingsely and S. Umans, Electrical Machines, McGraw Hill, 2017, 6th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106073/
2. https://nptel.ac.in/courses/115/101/115101005/
3. https://nptel.ac.in/courses/108/106/108106023/

CS1101 **3-0-0 (3)**

Programming and Data Structures

Pre-Requisites: None

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching and sorting.
CO-2	Compare and contrast algorithms in terms of space and time complexity for solving simple mathematical problems.
CO-3	Develop efficient algorithms using internals of computing systems.
CO-4	Examine the suitability of data types and structures for solving specific problems.
CO-5	Apply control structures to develop modular programs for solving mathematical problems.
CO-6	Analyze the concept of Abstract Data Types for using in real time applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	1	1	1	2	1	-	-	-	-	3	3	3
CO-2	2	1	2	1	2	3	-	-	-	-	3	3	2
CO-3	1	2	2	2	2	1	-	-	-	-	3	3	2
CO-4	2	2	2	2	2	2	-	-	-	-	2	3	2
CO-5	2	2	3	1	2	2	-	-	-	-	2	3	2
CO-6	2	2	3	2	2	2	-	-	-	-	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Computers: Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques: Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Number systems and data representation.

Elements of C++ programming language: Data types, constants, and variables, expressions and assignment statements, input and output statements, conditional and branch statements: If-else, Switch-case constructs, iteration statements: while, do-while, for, Arrays – Single and Multi-Dimensional Arrays, strings. Bit-wise operations.

Functions and Recursion: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, passing arrays as parameters to functions Recursion.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Pointers and Files: Introduction to pointers and dynamic allocation, String processing, File operations- create, read and write.

Searching and sorting: Linear and binary search, selection sort, bubble sort, insertion sort, merge sort, quick sort.

Data structures: Abstract Data Types (ADTs) - Stack ADT- Array-Based Implementation of Stack - Applications, Queue ADT - Array-Based Implementation – Applications.

Learning Resources:

Text Books:

1. Walter Savitch, "Problem Solving with C++", Pearson, 2018, 10th Edition.
2. Cay Horstmann, Timothy Budd, "Big C++", Wiley, 2009, 2nd Edition.
3. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
4. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Pearson Education, 2006, 3rd Edition.

BT1161 **2-0-0 (2)**

Biology for Engineers

Pre-Requisites: None

Course Outcomes:

CO-1	Realize the significance of biomolecules for sustaining life
CO-2	Identify the difference between unicellular to multi-cellular organisms
CO-3	Analyze heredity, variation and central dogma of life
CO-4	Apply the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	2	–	–	2	–	–	2	–	3	3	3
CO-2	3	2	2	–	–	2	–	–	–	–	3	3	3
CO-3	3	2	2	–	–	2	–	–	–	–	3	3	3
CO-4	3	3	2	2	1	2	1	–	2	–	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Molecules of Life: Chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell, Inside the cell, Cell cycle and Division.

Information processing in living system: Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

Biomolecular machines and motors: Cytoskeletal motor proteins, ATP synthase, Cell motility.

Applied Biotechnology: Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology.

Learning Resources:

Text Books:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

CS1103 **0-1-2 (2)**

Programming and Data Structures Lab

Pre-Requisites: CS1101

Course Outcomes:

CO-1	Design and test programs for solving mathematical and scientific problems
CO-2	Develop and test programs using control structures
CO-3	Implement modular programs using functions
CO-4	Develop programs using classes
CO-5	Develop ADT for stack and queue applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	2	1	2	1	-	-	-	-	-	3	3
CO-2	1	1	2	1	2	2	-	-	-	-	-	3	3
CO-3	1	2	3	2	2	1	-	-	-	-	-	3	3
CO-4	2	2	2	2	2	3	-	-	-	-	-	2	3
CO-5	2	2	2	2	2	3	-	-	-	-	-	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.
8. Programs of Stack and Queue.

Learning Resources:

Text Books:

1. Walter Savitch, "Problem Solving with C++", Pearson, 2014, 9th Edition.
2. Cay Horstmann, Timothy Budd, "Big C++", Wiley, 2009, 2nd Edition.
3. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
4. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Pearson Education, 2006, 3rd Edition.

2nd Semester

MA1162 **3-0-0 (3)**

Integral Calculus, Vector Calculus and Laplace Transforms

Pre-requisites: MA1161

Course Outcomes:

CO-1	Analyze improper integrals for extracting certain properties of beta and gamma integrals.
CO-2	Evaluate multiple integrals in different coordinate systems.
CO-3	Formulate engineering problems using the concepts of gradient, divergence and curl of scalar and vector point functions.
CO-4	Convert line integrals into area integrals and surface integrals into volume integrals.
CO-5	Solve physical problems arising in engineering by using-Laplace transforms.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-2	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-3	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-4	3	3	1	2	1	–	–	–	–	–	–	2	2
CO-5	3	3	1	2	1	–	–	–	–	–	–	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Integral Calculus: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, Change of order of integration; Change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; Vector differentiation; Level surfaces; Directional derivative; Gradient of a scalar field; Divergence and curl of a vector field; Laplacian operator; Parametrization of curves and surfaces; Line, surface and volume integrals; Green's theorem in a plane; Stoke's theorem; Gauss divergence theorem.

Laplace Transforms: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem; Applications of Laplace transforms - solving certain initial value problems - solving system of linear differential equations - finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses.

Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, 9th Edition.
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition.

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, 13th Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition.

CY1161 **3-0-2 (4)**

Engineering Chemistry

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic concepts of chemistry relevant to materials.
CO-2	Apply electrochemical concepts for energy harvesting, conversion and storage.
CO-3	Analyze the properties of materials for various applications.
CO-4	Analyze the principles of instrumentation, spectroscopy, and material characterization techniques.
CO-5	Analyze the redox process involved in metal extraction from ores.
CO-6	Determine the rate of corrosion by a redox reaction using the concept of adsorption.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	-	-	-	-	-	-	-	-	-	2	-	1
CO-2	3	-	-	-	-	-	-	-	-	2	2	1	1
CO-3	3	2	-	-	-	-	-	-	-	2	2	1	1
CO-4	3	-	-	-	-	-	-	-	-	2	2	1	2
CO-5	3	3	3	-	2	2	-	-	-	1	1	-	-
CO-6	3	3	3	-	2	2	-	-	1	1	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Chemical Kinetics and Thermodynamics: Order of a Reaction, Theories of Reaction Rates. Homogeneous and Heterogeneous Catalysis. Thermodynamic variables, Laws of Thermodynamics, Thermodynamic Relationships and Applications.

Electrochemistry and Energy Systems: Introduction to Electrochemistry, Nernst's law and its applications. Batteries, fuel cell and photo-electrochemical systems. Corrosion and its prevention. **Transition Metal Chemistry and Organometallic Chemistry:** Bonding in transition metal complexes; Crystal field and MO Theories, Jahn-Teller effect. Properties of Coordination complexes; Metal Carbonyls, EAN and 18-electron rule, Ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion, Hydrogenation, Hydro formylation, Monsanto process and Wacker process.

Engineering Materials: Inorganic and Organic Semiconductors, Magnetic materials, Liquid crystals, Superconductors, Photo conducting Materials and conducting polymers. **Chromatographic and Spectroscopic Methods:** Liquid Chromatographic and Gas Chromatographic methods. UV-VIS, spectroscopy, Infrared spectroscopy, NMR spectroscopy.

List of Experiments:

1. Standardization $KMnO_4$ solution
2. Estimation of metal content in an ore
3. Estimation of Calcium in milk powder by complexometry
4. Extraction and identification of DNA from green peas/onions
5. Estimation of iodine in iodized common salt
6. Blue printing of an object by photochemical reaction
7. Kinetics of acid hydrolysis of methyl acetate
8. Determination of acid strength in citrus fruit
9. Verification of Beer-Lambert Law and estimation of concentration of food color
10. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell
11. Estimation of phosphoric acid in soft drinks by pH metry
12. Separation of natural pigments from mixture using paper chromatography
13. Determination of efficiency of a corrosion inhibitor
14. Verification of Freundlich adsorption isotherm
15. Preparation of a polymer and its analysis
16. Estimation of active pharmaceutical ingredient in a drug

Learning Resources:

Text Books:

1. Shashi Chawla, A Text Book of Engineering Chemistry, Danpathrao & Co. Publications, 2007, 6th Edition.
2. Ashutosh Kar, Text Book of Engineering Chemistry, ED-Tech Publications, 2018.
3. William Kemp, Organic Spectroscopy, Macmillan Education, Limited, 2017.
4. Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Charles Corwin, Pearson Education, 2012.
5. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 2006.

Reference Books:

1. Michael F. Ashb, David R.H. Jones, Engineering Materials, Elsevier Science, 2012.
2. V. Raghava, Material Science and Engineering, PHI Learning, 2015.
3. J.M. Martin, Materials for Engineering, Elsevier Science, 2006.
4. Peter Atkins, Julio de Paula, James Keeler, Physical Chemistry, Oxford University Press, 2018.

CY1161 **0-0-2 (-)**

Engineering Chemistry Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Select a suitable methodology for the estimation of metal content, iodine content, or hardness of water
CO-2	Analyse acids, bases, redox compounds, etc. using instrumental methods
CO-3	Determine the concentration/corrosion inhibitor efficiency/adsorption isotherm of selective compounds and processes

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	-	-	-	-	-	-	-	-	-	2	-	1
CO-2	3	-	-	-	-	-	-	-	-	2	2	1	1
CO-3	3	2	-	-	-	-	-	-	-	2	2	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Standardization $KMnO_4$ solution
2. Estimation of metal content in an ore
3. Estimation of Calcium in milk powder by complexometry
4. Extraction and identification of DNA from green peas/onions
5. Estimation of iodine in iodized common salt
6. Blue printing of an object by photochemical reaction
7. Kinetics of acid hydrolysis of methyl acetate
8. Determination of acid strength in citrus fruit
9. Verification of Beer-Lambert Law and estimation of concentration of food color
10. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell
11. Estimation of phosphoric acid in soft drinks by pH metry
12. Separation of natural pigments from mixture using paper chromatography
13. Determination of efficiency of a corrosion inhibitor
14. Verification of Freundlich adsorption isotherm
15. Preparation of a polymer and its analysis
16. Estimation of active pharmaceutical ingredient in a drug.

Learning Resources:

Text Books:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 2006.

HS1161 **2-0-2 (3)**

English for Technical Communication

Pre-Requisites: None

Course Outcomes:

CO-1	Communicate effectively in diverse environments using technical communication principles.
CO-2	Analyze complex technical documents to extract and synthesize key information.
CO-3	Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports.
CO-4	Demonstrate use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions.
CO-5	Interpret technical data presented in the form of graphs, pie charts, and diagrams.
CO-6	Critique and provide constructive feedback on peer communication performances and written works.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	–	–	–	–	–	2	–	3	3	–	3	–	–
CO-2	–	–	–	–	–	–	–	3	3	–	3	–	–
CO-3	–	–	–	–	–	–	–	3	3	–	3	–	–
CO-4	–	–	–	2	–	–	–	3	3	–	3	–	–
CO-5	–	–	–	–	–	–	–	3	3	–	3	–	–
CO-6	–	–	–	–	–	–	–	3	3	–	3	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Grammar Principles & Effective Sentence Construction: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- Strategies for Bringing Variety and Clarity in Sentences, - Removing Ambiguity, - Editing Long Sentences for Brevity and Clarity, - Reported Speech, - Contexts for Use of Reported Speech, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

Writing- Paragraph & Letter: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development. - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

Reading Techniques: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

Technical Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy, and Wordiness, - Kinds of Graphics and Their Messages, - Suitability for Placement in Graphic Representation, - Introduction to Basic Concepts in Research, - Abstract, Keywords, Methodology, Hypothesis, Plagiarism, Critical Reading, - Abstract Writing, - How to Read Scientific Articles, - Basics of Writing a Research Project Proposal, - Preparation and Presentation of Project Reports

Reviews: Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, - Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms

Language laboratory

English Sound System -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription.

Stress and Intonation –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises

Introducing oneself in formal and social contexts- Role plays. - their uses in developing fluency and communication in general.

Oral presentation - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.

Listening Comprehension- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.

Debate/ Group Discussions-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, Drafting – the mindset to avoid writer's block, Checking your own reports and presentations, Giving and receiving constructive feedback.

Learning Resources:

Text Books:

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2) Orient Blackswan 2010.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006.
3. Meenakshi Raman and Sangeetha Sharma. Technical Communication: Principles and Practice 2nd Edition, Oxford University Press, 2011.
4. Tan, Zhongchao. Academic Writing for Engineering Publications: A Guide for Non-native English Speakers. Springer, 2022.

CE1164 **3-0-0 (3)**

Basic Engineering Mechanics

Pre-Requisites: None

Course Outcomes:

CO-1	Determine the resultant force and moment for a given planar and spatial force system.
CO-2	Derive the equilibrium equations for planar and spatial rigid bodies in equilibrium.
CO-3	Evaluate the friction problems for planar bodies in equilibrium.
CO-4	Analyze the kinetics and kinematic characteristics of rigid bodies in motion.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	1	1	1	1	1	1	1	1	1	1	1	2	1
CO-2	1	1	1	1	1	1	1	1	1	1	1	2	2
CO-3	2	1	1	2	2	2	2	2	2	2	2	2	1
CO-4	2	2	1	1	1	1	1	1	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom

- Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints

– Free body diagrams.

Spatial Force systems - Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system – Problems.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Dynamics of Particles - Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Curvilinear Motion – Normal and tangential components.

Learning Resources:

Text Books:

1. S. Timoshenko, D.H. Young, J.V. Rao and Sukumar Pati, Engineering Mechanics (In SI Units) McGraw Hill Publishers, 2017, 5th Edition.
2. Ferdinand P. Beer, E. Russell Johnston Jr., et al., Vector Mechanics for Engineers - Statics and Dynamics, McGraw Hill Publishers, 2019, 12th Edition.

Reference Books:

1. J.L.Meriam and L.G. Kraige, Engineering Mechanics (Statics), John Wiley &Sons, 2017, 7th Edition.
2. J.L.Meriam and L.G. Kraige, Engineering Mechanics (Dynamics), John Wiley &Sons, 2018, 7th Edition.
3. R. C. Hibbeler, Mechanics of Materials (SI Edition), Pearson pub, 2018.
4. J. L. Meriam, L. G. Kraige, et al., Engineering Mechanics: Statics, SI Version, Wiley India Edition, 2017.
5. J.L. Meriam, L.G. Kraige, et al., Engineering Mechanics: Dynamics, SI Version, Wiley India Edition, 2018.
6. S.S. Bhavikatti, Engineering Mechanics, New Age International Private Limited, 2021, 8th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/104/122104015/
2. https://nptel.ac.in/courses/112/106/112106180/

EE1102 **0-1-4 (3)**

Design Thinking

Pre-Requisites: None

Course Outcomes:

CO-1	Understand and address the user's needs and dissatisfaction.
CO-2	Formulate the problems to stimulate ideation.
CO-3	Ideate on problems to propose solutions by working collaboratively.
CO-4	Analyze the aspects of the proposed solutions.
CO-5	Enhance solutions based on the user's feedback.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	3	3	3	2	3	3	2	3	2	3
CO-2	2	2	2	3	3	3	2	3	3	2	3	2	3
CO-3	2	2	2	3	3	3	2	3	3	2	3	2	3
CO-4	2	2	2	3	3	3	2	3	3	2	3	2	3
CO-5	2	2	2	3	3	3	2	3	3	2	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Engineering: "Engineering" as a vehicle for social and economic development; impact of science/engineering our day to day lives; process of engineering a product; various career options.

Introduction and identifying the need:

Identifying the needs of the society in various aspects and formulating the modifications for better performance of existing products and also conceptualizing new products.

Case studies:

- Study of transportation systems and development of Electric Vehicle.

  Ex: Development in electrical motors for EVs, power controllers, automobile lighting systems, battery related aspects.
- Induction heating systems: Requirements and developments of heating systems for domestic and industrial applications.
- Lighting Systems: Development of lighting systems from incandescent bulbs to LED lighting systems.
- Renewable energy systems: Need for alternate energy sources and their development. Desirable features of energy sources and their utilization.
- Understanding the unique needs of the user - empathize - define - ideate - prototype - test. Case Studies - Develop appreciation for the design process and its application in specific settings (Guest lectures, Videos, Field visits, Interplay lectures of design-based movies).

Problem Formulation: Framing a problem statement neutrally using adequate checks. Case studies. Clarify objectives, establish requirements, identify constraints, establish steps for implementation.

Concept Generation: Generate multiple concepts,

Case studies: Examples

- Heating applications: production of heat by burring gas, coal, wood, microwave, induction heating-finding suitability of each solution for particular situation.
- Generation of Electric Power: Alternative energy solutions based on the availability

Prototyping: select from ideas and make quick prototypes (mock-ups) using available ratings of the components.

Case studies: Examples

Design of voltage regulator using Zener diode.

Design of L-C filter for rectifiers

Evaluation: Iterative process of ideation, prototyping and testing-Take the mock-ups to users for feedback and iterate process till users feel delighted.

Activities:

Some of the activities which are undertaken as a part of this course include:

- Field Visits
- Case Studies on innovation, failures etc.
- Guest lecture
- Group Discussions
- Presentation by student
- Experiential learning
- workshops

Learning Resources:

Text Books:

1. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st Edition.
2. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Tim Brown, Harper Business, 2019.
3. Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 2019, 5th Edition.
4. Product design and development, Ulrich, K., Eppinger, S. and Yang, M., 2020, 7th Edition.

Other Suggested Readings:

1. https://www.arvindguptatoys.com/
2. https://honeybee.org/
3. https://dschool.stanford.edu/resources/getting-started-with-design-thinking
4. https://designthinking.ideo.com/

EE1104 **3-0-0 (3)**

Electrical Circuits – I

Pre-Requisites: None

Course Outcomes:

CO-1	Apply network equations, graph theory, and duality concepts to electrical circuit analysis.
CO-2	Analyze magnetic circuits, steady-state responses, and resonance characteristics of AC circuits.
CO-3	Evaluate the transient response of first-order and second-order electrical circuits using time domain techniques.
CO-4	Solve transient response of electrical circuits using Laplace transform techniques

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	2	1	1	1	1	2	3	1
CO-2	3	3	3	3	3	2	1	1	1	1	2	3	1
CO-3	3	3	3	3	3	2	1	1	1	1	2	3	1
CO-4	3	3	3	3	3	2	1	1	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Circuit Elements and Relations: Types of circuit components, KVL and KCL, Types of Sources and Source Transformations, Star-delta transformation, DC circuit analysis, Formation of loop and node equations, Graph of a network, Incidence matrix, Dual- networks.

Magnetic Circuits: Concept of MMF, flux and magnetic reluctance, Self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

Steady State Analysis of Circuits for Sinusoidal Excitations: Concept of phasors, Single phase Series, Parallel, Series Parallel circuits, Concept of power factor, Solution of AC networks using mesh and nodal analysis, Phasor diagrams, 3-phase balanced and unbalanced network analysis, Neutral voltage calculations, complex power.

Resonance: Series and Parallel resonance, Bandwidth, Q-factor and selectivity.

Time Domain Analysis: Solution of network equations in time domain, Classical differential- equations approach, Initial conditions & evaluation, applications to simple RLC circuits only.

Applications of Laplace Transforms in Circuit Theory: Laplace transforms of various signals of excitation, Laplace transformed networks, determination and representation of initial conditions, Waveform synthesis, Response for impulse function and its relation to network admittance, Convolution integral and applications.

Learning Resources:

Text Books:

1. M.E.Van Valken Burg, Network Analysis, Pearson Education, 2015, 3rd Edition.
2. William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw Hill, 2013, 8th Edition.
3. De Carlo, Lin, Linear circuit Analysis, Oxford University Press, 2010, 2nd Edition.

Reference Books:

1. Alexander C.K., Sadiku M.N.O., Fundamentals of Electric Circuits, McGraw Hill Education, 2019, 6th Edition.
2. Joseph A. Edminister, Mahmood Nahvi, Electric Circuits, Schaum's series, McGraw-Hill Education, 2017, 5th Edition.
3. S.R. Paranjothi, Electric Circuit Analysis, New Age International Publications, 2011, 4th Edition.
4. G.K Mittal, Ravi Mittal Network Analysis, Khanna Publications, 2003, 14th Edition.
5. M.L. Soni, J.C. Gupta, A Course in Electrical Circuits Analysis, Dhanpat Rai & Co., 2001.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/106/108106172/

ME1165 **0-1-2 (2)**

Engineering Workshop Practice

Pre-Requisites: None

Course Outcomes:

CO-1	Identify workshop tools and their operational capabilities Credits
CO-2	Practice on manufacturing of components using workshop trades including fitting, foundry and welding
CO-3	Apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO-4	Apply basic electrical engineering knowledge for House Wiring Practice

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	-		1	-	2	2	-	-	2	-
CO-2	3	3	1	-	2	1	-	2	2	-	-	2	-
CO-3	3	3	1	-	2	1	-	2	2	-	-	2	-
CO-4	3	3	1	-	2	1	-	2	2	-	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Demonstration: Safety practices and precautions to be observed in workshop.

Fitting Trade: Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint. Carpentry: Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint and Mortise Tenon Joint.

Machine shop: Demonstration and practice on Lathe Machine, Preparation of work pieces involving Facing, Plane Turning, step turning, knurling and parting operations.

House Wiring: Demonstration and practice on Electrical tools, wiring and earthing, Exercises on Staircase Wiring & Godown wiring.

Power Tools: Demonstration and practice on Power tools (Bosch Power Tools) and Safety Practices.

Foundry Trade: Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.

Welding Shop: Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

Learning Resources:

Text Books:

1. Felix W., Basic Workshop Technology: Manufacturing Process, Independently Published, 2019.
2. Bruce J. Black, Workshop Processes, Practices and Materials, Routledge publishers, 5th Edition. 2015.
3. B.S. Raghuwanshi, A Course in Workshop Technology Vol I. & II, Dhanpat Rai & Co., 2015 & 2017.

Reference Books:

1. S. K. Hajra Choudhury, and Nirjahar Roy, Elements of Workshop Technology, Vol. I, Media Promoters and Publishers, Mumbai. 2007, 14th Edition.
2. S. K. Hajra Choudhury and Nirjahar Roy, Elements of Workshop Technology, Vol. II, Media Promoters and Publishers, Mumbai. 2007, 12th Edition.
3. H. S. Bawa, Workshop Practice Tata-McGraw Hill, 2004.
4. Steve F. Krar, Arthur R. Gill and Peter Smid, Technology of machine tools, McGraw Hill Education (India) Pt. Ltd., 2013.
5. Ramesh Babu.V., Engineering Practices Laboratory Manual, VRB Publishers Private Limited, Chennai, Revised edition, 2013 – 2014.
6. T.Jeyapoovan, Engineering Practices Lab Manual; Vikas Publishers, 2008, 4th Edition.
7. John K.C., Mechanical Workshop Practice; PHI, 2010.
8. Soni P.M. & Upadhyay P.A.; Atul Prakashan, Wiring Estimating, Costing and Contracting; 2021-22.

Other Suggested Readings:

1. Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India. (https://bharatskills.gov.in).

3rd Semester

MA1261 **3-0-0 (3)**

Fourier Series, Partial Differential Equations and Complex Variables

Pre-requisites: MA1162

Course Outcomes:

CO-1	Obtain the Fourier series for a given function
CO-2	Find the Fourier transform of a function
CO-3	Determine the solution of a PDE by variable separable method
CO-4	Apply complex variables in mathematical and engineering applications
CO-5	Evaluate a real definite integral

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	3	1	2	1	–	–	–	–	–	–	2	2
CO-2	3	2	1	2	1	–	–	–	–	–	–	2	2
CO-3	2	3	1	3	1	–	–	–	–	–	–	2	2
CO-4	3	2	1	2	1	–	–	–	–	–	–	2	2
CO-5	3	2	1	2	1	–	–	–	–	–	–	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fourier Series: Introduction and basic definitions; Expansion of a function in Fourier series for a given range; Half range sine and cosine expansions.

Partial Differential Equations: Classification of higher order partial differential equations; Method of separation of variables - Solution of one-dimensional wave equation, one-dimensional heat conduction equation and two-dimensional steady state heatconduction equation with illustrations.

Complex Variables: Analytic function – Cauchy-Riemann equations, Harmonic functions, Conjugate functions; Complex integration - Line integrals in complex plane, Cauchy's theorem (simple proof only) and Cauchy's integral formula; Taylor's and Laurent's series expansions; Zeros and singularities; Residues - Residue theorem, Use of residue theorem to evaluate the real definite integral of the type $\int_0^{2\pi} f(cos\theta,\ sin\theta)d\theta$ and $\int_{-\infty}^{\infty} f(x)dx$. Concept of conformal mapping with simple illustrations.

Learning Resources:

Text Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition.
3. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, McGraw Hill Education, 2009, 9th Edition

Reference Books:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition.
2. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand & Co., 2024, 12th Edition.

EE1201 **3-0-0 (3)**

Electrical Circuits – II

Pre-Requisites: EE1104

Course Outcomes:

CO-1	Simplify the analysis of electric circuits using network theorems
CO-2	Determine the driving point immittance of single-port networks in frequency domain using poles and zeros
CO-3	Analyze and simplify two-port networks using their properties and interrelationships
CO-4	Analyze electric circuits with periodic and aperiodic excitations using Fourier series and Fourier Transformation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	2	1	1	1	1	3	3	2
CO-2	3	3	3	3	3	2	1	1	1	1	3	3	2
CO-3	3	3	3	3	3	2	1	1	1	1	3	3	2
CO-4	3	3	3	3	3	2	1	1	1	1	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Network Theorems: Superposition theorem, Reciprocity theorem, Thévenin's theorem, Norton's theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem.

Network Functions: Driving point impedance and transfer functions of 1-port RLC Networks, Natural frequencies of a network, Poles and Zeros of driving point impedances.

Two Port Networks: Impedance, admittance, transmission and hybrid parameters of two-port networks and inter-relationship.

Analysis of Electric Circuits with Periodic Excitation: Review of Fourier series and evaluation of Fourier coefficients, Trigonometric and complex Fourier series for repetitive waveforms, concept of harmonic power.

Applications of Fourier Transforms for Electrical Circuits: Amplitude and phase spectra, Fourier transforms and Parseval's theorem and application to network analysis with aperiodic excitations.

Learning Resources:

Text Books:

1. Van Valkenburg, Network Analysis, M.E. Pearson Education; April 2019, Revised 3rd Edition.
2. N.C. Jagan, C. Lakshminarayana, Network Theory, BS publications, 2015, 3rd Edition.
3. Durgesh C. Kulshreshtha Gopal G. Bhise, Prem R. Chadha, Engineering Network Analysis and Filter Design Including Synthesis of One Port Networks, Umesh Publications; January 2012

Reference Books:

1. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill Education; April 2018, 9th Edition.
2. John Bird, Electrical Circuit Theory and Technology, Routledge; October 2021, 7th Edition.

Other Suggested Readings:

1. https://www.digimat.in/nptel/courses/video/108105159/L01.html
2. https://www.digimat.in/nptel/courses/video/108102042/L01.html

EE1203 **3-0-0 (3)**

Electrical Machines – I

Pre-Requisites: None

Course Outcomes:

CO-1	Understand operation of DC machines, single-phase and three-phase transformers and auto transformers.
CO-2	Analyze starting methods and speed control of DC machines.
CO-3	Analyze parallel operation of DC generators, single-phase and three- phase transformers
CO-4	Evaluate the performance of DC machines and transformers.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	1	1	2	1	1	1	1	2	3	2
CO-2	3	3	3	1	1	2	1	1	1	1	2	3	2
CO-3	3	3	3	2	1	2	1	1	1	1	2	3	2
CO-4	3	3	3	2	2	2	1	1	1	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Electromechanical Energy Conversion Principles: Principles of energy conversion, single excited and doubly excited magnetic systems, singly excited electric field systems. Constructional features of rotating electrical machines, generating EMF, emf polygon, MMF produced by distribution windings, concepts of torque production.

DC Machines: Constructional features, parts of DC machines, Simplex and multiplex lap and wave windings; Methods of excitation, characteristics of saturated and un-saturated series, shunt, cumulatively and differentially compound excited machines operating as motors and generators, applications of DC machines; Armature reaction, demagnetizing and cross magnetizing ampere-turns, compensating windings, commutation process and methods of commutation, role of inter poles and compensating winding. Problems on emf equation, torque equation and armature reaction. Principle of operation of cross-field Generators-Amplidyne-Metadyne.

Speed Control of DC Motors: Speed control of shunt & series motors, losses in DC machines and calculation of efficiency. Need for starters and Starters for DC series shunt and compound motors.

Testing of DC Motors: No-load test, load tests and regenerative tests such as Swinburne's Test, Direct load test, Hopkinson's test, Field's test and Retardation test. Calculation of efficiency based on all the above tests.

Single-Phase Two Winding Transformers: Construction, principle of operation, E.M.F. equation, phasor diagrams; Equivalent circuit, determination of equivalent circuit parameters, Predetermination of performance equivalent circuit parameters and Sumpner's test. Losses, separation of no-load losses, calculation of efficiency and regulation by direct and indirect methods, conditions for maximum efficiency. Concept of all-day efficiency. Parallel operation of transformers and Load sharing.

Auto transformer: Principle of operation, saving of copper compared to two-winding transformer and applications.

Three-Phase Transformers: Merits of three phase Transformers over three phase transformer bank Type of connections such as Delta-Delta, Delta-Star, Star-Delta, Delta-Star, V-V connection and T-T Connections. Relation between line and phase voltages and currents, Vector Groups, use of tertiary winding. Three phase to Two phase connections and vice-versa. Problems on three phase transformers.

Learning Resources:

Text Books

1. Dr. P. S. Bimbhra, Electrical Machinery, Theory: Performance & Applications, Khanna Publishers, 2021.
2. Stephen D. Umans, Fitzgerald and Kingsley's electric machinery, TMH Publishers, 7th Edition, 2020.

Reference Books:

1. Nagarath & D.P.Kothari, Electrical Machines, TMH Publishers, 2017, 5th Edition.
2. J.B. Gupta, Theory & Performance of Electrical Machines, S.K. Kataria & Sons, 2013, 5th Edition.
3. A.E .Clayton & NN Hancock, The Performance and Design of Direct Current Machines, CBS Publishers, 2004.
4. P. S Bimbhra, Electric Machines, Khanna Publishers, 2017, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105155/
2. https://nptel.ac.in/courses/108/105/108105017/
3. https://nptel.ac.in/courses/108/106/108106071/

EE1209 **3-0-2 (4)**

Electrical Measurements and Instrumentation

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the operating principles and performance of PMMC, MI, dynamometer type & induction type measuring instruments.
CO-2	Determine the circuit parameters using AC and DC bridges.
CO-3	Evaluate the errors in CTs and PTs under different operating conditions.
CO-4	Analyze sensors and the operation of electronic measuring instruments.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	2	1	1	1	1	2	2	3	3	3
CO-2	3	3	3	3	1	1	1	2	1	1	1	3	3
CO-3	3	3	3	3	2	2	1	1	1	1	1	3	3
CO-4	3	3	3	3	1	2	1	2	1	1	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Measurement standards and units, definitions, classification of electromechanical and digital instruments**.**

Electromechanical meters: PMMC, MI, electrodynamometer and induction-type instruments: construction, working, types, torque equation, range extension, errors, advantages and disadvantages, active- and reactive- power measurements in single-phase and three-phase circuits.

DC & AC bridges: Introduction to bridge circuits; Wheatstone bridge, Kelvin's bridge, megger, loss of charge method; Maxwell's bridges, Anderson bridge, Schering bridge, De-Sauty bridge, Wien bridge; limitations and applications.

Instrument Transformers: Construction, types, working, equivalent circuit, errors, phasor diagram, testing and applications.

Transducers: Classification, types, thermistor, RTD, thermocouple, LVDT, strain gauge, piezoelectric transducers, digital shaft encoders, tachometer, Hall effect sensors; applications.

Electronic instruments: Introduction to digital instruments, structure, types, sensitivity and detection of signals; digital voltmeters, dual-trace and dual-beam CRO, measurement of voltage and frequency, Lissajous patterns, wave analyzers, harmonic distortion analyzer, LCR meter and Q-meter.

Smart instruments: Intelligent transducer, self-diagnosis and remote calibration features, HART communication, MEMS, non-linearity compensation; smart energy meter components, working principle; Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI) environments.

Learning Resources:

Text Books

1. E. W. Golding, F. C. Widdis, Electrical Measurements and Measuring Instruments, Reem Publications Pvt. Ltd., 2011, 3rd Edition.
2. K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co., 2020, 19th Edition.
3. Albert D. Helfrick, William D. Cooper, Modern Electronic instrumentation and Measurements Techniques, Pearson Education India, 2016, 1st Edition.

Reference Books:

1. S.C. Bhargava, Electrical Measuring Instruments and Measurements, BS Publications, 2013, 1st Edition.
2. Ernest O. Doebelin, Dhanesh N. Manik, Measurement systems, McGraw Hill India, 2019, 7th Edition.
3. R. K. Rajput, Electrical and Electronic Measurements and Instrumentation, S. Chand & Co. Ltd., 2015, 4th Edition.
4. H S Kalsi, Electronic Instrumentation and Measurements, McGraw Hill, 2019, 4th Edition.
5. Arun K. Ghosh, Introduction to Measurements and Instrumentation, Eastern Economy Edition, PHI Learning, 2012, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105153/
2. https://www.cdac.in/index.aspx?id=pe_pe_PEG_SMARTENERGY

EE1209 **0-0-2 (-)**

Electrical Measurements and Instrumentation Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the measurement of current, voltage, power and frequency using analog instruments.
CO-2	Measure the resistance, inductance, and capacitance using electrical bridges.
CO-3	Determine the errors in instrument transformers.
CO-4	Measure temperature, displacement, pressure using suitable transducer.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	2	1	1	1	1	2	2	3	3	3
CO-2	3	3	3	3	1	1	1	2	1	1	1	3	3
CO-3	3	3	3	3	2	2	1	1	1	1	1	3	3
CO-4	3	3	3	3	1	2	1	2	1	1	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Study and observe the oscilloscope as a test and measuring instrument. (Test the resistors, capacitors, diodes, transistors, measure AC/DC voltages, frequency, phase and study the Lissajous patterns).
2. Plot the B-H curve of a magnetic specimen to obtain its hysteresis loss and calculate its Steinmetz's constant & co-efficient.
3. Calibration of 1-Φ induction-type energy meter by phantom loading.
4. Low resistance measurement using Kelvin double bridge.
5. Measurement of inductance using Maxwell's bridges and Anderson bridge.
6. Measurement of capacitance using Schering bridge and De-Sauty bridge.
7. Frequency measurement using Wein bridge.
8. Determination of ratio & phase error in a potential transformer.
9. Determination of ratio & phase error in a current transformer.
10. Temperature measurement using RTD, thermistor and thermocouple.
11. Measurement of pressure and weight using piezoelectric transducer.
12. Measurement of power factor using two-watt meter method.
13. Active power measurement in a balanced 3-Φ system using two wattmeter method.
14. Reactive power measurement in a balanced 3-Φ system using single wattmeter method.

Learning Resources:

Text Books

1. E. W. Golding, F. C. Widdis, Electrical Measurements and Measuring Instruments, Reem Publications Pvt. Ltd., 2011, 3rd Edition.
2. K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co., 2020, 19th Edition.
3. Albert D. Helfrick, William D. Cooper, Modern Electronic instrumentation and Measurements Techniques, Pearson Education India, 2016, 1st Edition.

Reference Books:

1. S.C. Bhargava, Electrical Measuring Instruments and Measurements, BS Publications, 2013, 1st Edition.
2. Ernest O. Doebelin, Dhanesh N. Manik, Measurement systems, McGraw Hill India, 2019, 7th Edition.
3. R. K. Rajput, Electrical and Electronic Measurements and Instrumentation, S. Chand & Co. Ltd., 2015, 4th Edition.
4. H S Kalsi, Electronic Instrumentation and Measurements, McGraw Hill, 2019, 4th Edition.
5. Arun K. Ghosh, Introduction to Measurements and Instrumentation, Eastern Economy Edition, PHI Learning, 2012, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105153/
2. https://www.cdac.in/index.aspx?id=pe_pe_PEG_SMARTENERGY

EC1261 **3-0-0 (3)**

Analog Electronics

Pre-Requisites: None

Course Outcomes:

CO-1	Compare the characteristics of different semiconductor devices.
CO-2	Identify the applications of semiconductor devices
CO-3	Analyze the characteristics and parameters of operational amplifiers.
CO-4	Design linear and non-linear application circuits of operational amplifier
CO-5	Analyze the operation of 555 timer and 723 voltage regulator .
CO-6	Analyze analog electronic circuits using experimental boards.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	1	1	1	1	-	-	1	1	1	1	1	1
CO-2	1	3	3	3	1	-	-	3	1	1	1	2	2
CO-3	3	3	3	1	1	-	-	1	1	1	1	1	1
CO-4	1	3	3	3	1	-	-	3	2	1	2	2	2
CO-5	3	3	3	1	1	-	-	1	1	1	1	1	2
CO-6	1	1	1	1	1	-	-	3	1	1	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to electronics: Overview of semiconductor physics, review of P-N junction operation, Characteristics of PN-Junction diode, Zener diode, LED, Diac, Triac, SCR and Solar cell. Zener diode as a voltage regulator

Diode Applications: Half wave, full wave and bridge rectifiers with filters (C, L, LC and π), Clippers and clampers.

BJT- CE, CB and CC configurations, CE Transistor Characteristics, Low frequency h- parameter model and analysis, Transistor Biasing, Stability and Thermal Runaway; Transistor as switch. **JFET** Characteristics, **MOSFET**: Enhancement and depletion mode characteristics. Differential amplifier.

Feedback Amplifiers: feedback topology-Voltage series, voltage shunt, current series, current shunt, stability, positive feedback, Bark hausen criterion, Introduction to oscillators- RC& LC oscillators and crystal oscillator.

Power Amplifiers: Classification of power amplifiers, class-A and class-B push- pull amplifiers, harmonic distortion and cross-over distortion in power amplifiers.

Integrated circuits: Introduction, Operational amplifiers (**μA-741**)-Ideal and practical characteristics and linear applications.

Learning Resources:

Text Books:

1. Millman's Integrated Electronics, McGraw Hill Education, 1 July 2017, 2nd Edition.
2. Basic Electronics & Linear Circuits, Bhargava N. N., D C Kulshreshtha and S C Gupta, Tata McGraw Hill, 2013, 2nd Edition.

Reference Books:

1. D. Roy Choudhury and Shail B. Jain, Linear Integrated Circuits, 4th Edition New Age International Pvt. Ltd. 11 June 2017.

EC1265 **0-1-2 (2)**

Analog Electronics Lab

Pre-Requisites: EC1261

Course Outcomes:

CO-1	Evaluate the characteristics of semiconductor devices.
CO-2	Implement the applications of semiconductor devices.
CO-3	Evaluate the characteristics and parameters of operational amplifier
CO-4	Implement linear and non-linear application circuits of operational amplifier
CO-5	Analyze the operation of 555 timer and 723 voltage regulator.
CO-6	Implement analog electronic circuits using experimental boards.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	1	1	1	1	-	-	1	1	1	1	1	1
CO-2	1	3	3	3	1	-	-	3	1	1	1	2	2
CO-3	3	3	3	1	1	-	-	1	1	1	1	1	1
CO-4	1	3	3	3	1	-	-	3	2	1	2	2	2
CO-5	3	3	3	1	1	-	-	1	1	1	1	1	2
CO-6	1	1	1	1	1	-	-	3	1	1	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Lab Experiments:

1. Characteristics of PN junction diode
2. Rectifiers and filters.
3. Clippers and Clampers
4. Zener diode as a Voltage regulator
5. CE-BJT Characteristics
6. JFET Characteristics
7. Single stage BJT-RC Coupled amplifier
8. RC Phase Shift Oscillator
9. Operational Amplifier as an Inverting and non-inverting amplifier
10. Operational Amplifier applications

Learning Resources:

Text Books:

1. Millman's Integrated Electronics, McGraw Hill Education, 1 July 2017, 2nd Edition.
2. Basic Electronics & Linear Circuits, Bhargava N. N., D C Kulshreshtha and S C Gupta, Tata McGraw Hill, 2013, 2nd Edition.

Reference Books:

1. D. Roy Choudhury and Shail B. Jain, Linear Integrated Circuits, New Age International Pvt. Ltd. 11 June 2017, 4th Edition.

4th Semester

EE1202 **3-0-0 (3)**

Electrical Machines – II

Pre-Requisites: EE1203

Course Outcomes:

CO-1	Analyze the construction, operation, and characteristics of three-phase induction machines.
CO-2	Evaluate the performance of three-phase induction machines using equivalent circuits and performance characteristics.
CO-3	Analyze the construction, operation, and performance of three-phase synchronous machines
CO-4	Analyze the effects of excitation and mechanical input on the operation of synchronous machines.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	2	2	3	2	2	2	2	2	3	3
CO-2	3	3	3	2	2	3	2	2	2	2	2	3	3
CO-3	3	3	3	2	2	3	2	2	2	2	2	3	3
CO-4	3	3	3	2	2	3	2	2	2	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Three Phase Induction Machines: Constructional details, classification, principle of operation, production of rotating magnetic field and rating of induction motors, Phasor diagram, equivalent circuit, Pre-determination of performance from using equivalent circuit. Torque equations for starting, full load and maximum operating conditions, condition for maximum-output, slip for maximum-output, Torque-slip characteristics, losses & efficiency and applications. concepts of single phasing.

Starters-Auto transformer, star delta and rotor resistance starters. Tests on Induction Motor: No load and blocked rotor test-determination of equivalent circuit parameters, Pre-determination of performance from circle diagram.

Double cage induction motor: Construction, theory, equivalent circuit, characteristics and applications. Problems on torque calculations, losses and efficiency of squirrel cage, double cage and slip induction motors. Principle of operation of Schrage motor.

Induction Generator: Principle of operation, equivalent circuit and application.

Three Phase Synchronous Machines: Principle of operation of non-salient pole machines Constructional features, classification, ratings, winding factors, production of emf, harmonics, emf equation, Problems on emf equation, armature reaction, concepts of synchronous reactance, phasor diagrams for various operating conditions, no-load and load characteristics, open circuit and short circuit tests. Pre-determination of regulation-Synchronous impedance method, ampere-turn method, Potier triangle method and ASA and New ASA method. Problems non-salient pole synchronous generators.

Principle of operation of salient pole machines-Two reaction theory–analysis, Slip test, pre-determination of regulation of salient pole synchronous generator, phasor diagrams, analysis using phasor

diagrams. power-angle characteristics, synchronization and synchronizing power. Problems salient pole synchronous generators

Parallel operation and load sharing– effect of change in excitation, effect of change in power factor, operation on infinite bus-bar, typical applications.

Synchronous Motor: Principle of operation–phasor diagrams for various operating conditions, variation of current and power factor with excitation. Hunting and its suppression, determination and pre-determination of V and inverted V curves, methods of starting, losses and efficiency of salient and non-salient pole synchronous motors.

Learning Resources:

Text Books

1. Dr. P. S. Bimbhra, Electrical Machinery, Theory: Performance & Applications Khanna Publishers, 2021.
2. Nagarath & D.P.Kothari, Electrical Machines, TMHPublishers, 2017, 5th Edition.

Reference Books:

1. Charles A. Gross, Electric Machines, CRC Press, 2007.
2. Fitzgerald, Charles Kingsley, Stephen D. Umans, Electric Machinery, A.E. Sixth Edition TMH, 2009.
3. Charbs. I.Hubert Electric Machines, Pearson, 2003, 2nd Edition.
4. Stephen. J.Chapman, Electric Machinery, McGrawHill International Edition, 2005.
5. M.G.Say, Alternating Current Machines, Wiley, 1983.
6. Alexander. S. Langsdorf, Tata McGrawHill, Theory of Alternating Current Machine, 2009, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105131/
2. https://nptel.ac.in/courses/108/106/108106072/

EE1206 **3-0-0 (3)**

Control Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze electrical and electromechanical systems using the transfer function approach.
CO-2	Determine transient and steady-state behaviour of dynamic systems.
CO-3	Determine absolute and relative stability of dynamic systems using time & frequency domain analyses
CO-4	Design compensators for liner control systems to derive the specified steady-state and dynamic responses

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: System, control system, types of control systems, Transfer Function, open-loop and closed loop systems, types of feedback, feedback and its effects.

Modelling of Physical Systems: Mathematical modelling of Electrical and Electro- mechanical elements, D.C. motors. Block diagram illustration.

Techniques to Develop Transfer Function of Systems: Introduction, Block diagram reduction technique and signal flow graph, Mason's gain formula.

Time Domain Analysis of Control Systems: Introduction- time domain indices, steady state error constants, concept of BIBO stability, absolute stability. Routh- Hurwitz Criterion.

Root Locus Techniques: Introduction, Root loci theory, Application to system stability analysis. Illustration of the effect of addition of zero and pole.

Frequency Domain Analysis of Control Systems: Introduction, Bode plots, Frequency domain indices, application of Bode plots, Polar plots. P, PI & PID controllers.

State-Space Representation of Dynamic Systems: State-Variables, State-Variable representation of Electrical Systems.

Learning Resources:

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 2019, 7th Edition.

2. I.J. Nagarath & M. Gopal: Control Systems Engineering, New Age Pub. Co, 2017, 6th Edition.

Reference Books:

1. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 2015, 5th Edition.
2. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015, 13th Edition.
3. K. R. Varmah, Control Systems, McGraw Hill Education, 2010.
4. Dhanesh N Manik, Control Systems, Cengage Learning, 2012, 1st Edition.
5. B.C.Kuo: Automatic Control Systems, Wiley, 2014, 9th Edition.

Other Suggested Readings:

1. https://www.controleng.com
2. https://www.mathworks.com
3. https://nptel.ac.in/courses/108/102/108102043/

EE1212 **2–0–2 (3)**

Artificial Intelligence and Machine Learning

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the role of data in modern engineering systems through basic exploratory data analysis.
CO-2	Apply AI and ML concepts, including regression, classification, and clustering to simple datasets with interpretation of results.
CO-3	Describe the working principles of neural networks and major deep learning architectures.
CO-4	Analyze the capabilities and limitations of large language models and generative AI systems.
CO-5	Develop solutions to various AI and ML applications across different engineering and societal domains.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	2	2	-	-	-	1	-	2	2	1
CO-2	3	3	2	2	3	-	-	-	1	-	2	2	2
CO-3	2	2	3	2	3	-	-	-	1	-	2	3	2
CO-4	1	2	1	1	2	2	2	-	2	-	3	1	1
CO-5	3	3	3	2	3	2	1	1	2	1	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Pedagogical Approach

The course will adopt a balanced approach that combines conceptual lectures, demonstrations, case studies, and hands-on laboratory exercises. Application examples will be drawn from diverse engineering domains such as manufacturing, electronics, communication systems, civil infrastructure, healthcare, energy systems, and environmental monitoring to ensure relevance across all B.Tech disciplines.

The course aims to provide engineering students with foundational AI literacy and practical awareness of intelligent systems. It will enable students to effectively engage with AI technologies in their respective disciplines and will also serve as a foundation for advanced electives in artificial intelligence, machine learning, data science, and intelligent systems.

Course Syllabus

Data Analytics Foundations - Introduction to data and its role in engineering systems. Nature of the Data (e.g., sequence, time-series, temporal, spatial); Structured data: relational databases and NoSQL databases. Unstructured and semi-structured data: text, images, video, audio, and multimodal data. Data collection and preprocessing. Data visualization techniques. Statistical data analysis. Exploratory data analysis and interpretation of patterns in data.

Foundations of Artificial Intelligence - Introduction to Artificial Intelligence, Problem-solving agents and agent-based systems: perception, reasoning, and action; Search Vs Optimization, Classical AI approaches and rule-based systems. Introduction to machine learning. Supervised learning: regression and classification techniques. Unsupervised learning: clustering methods. Overview of learning paradigms (e.g., supervised, unsupervised, semi-supervised learning, reinforcement learning, and active learning). Evaluation of machine learning models.

Deep Learning and Applications - Basics of neural networks: perceptron, multilayer neural networks, backpropagation, gradient descent optimization. Introduction to deep learning. Overview of major deep learning architectures: sequence models for text analysis (RNN, LSTM), and convolutional neural networks for computer vision. Applications of deep learning (e.g., question answering, image classification, image captioning, and machine translation).

Generative and Agentic AI - Introduction to generative AI. Large language models and transformer architectures such as BERT and GPT. Prompt engineering and interaction with AI systems. Conversational AI and chatbots. Overview of agentic AI systems and autonomous AI assistants, Connect agents with modern **LLM-powered systems - Agentic AI systems and LLM-powered agents for task automation, tool use, and workflow orchestration.** Applications of transformer-based models in domains such as legal document analysis, text analytics, and knowledge extraction. Overview of Visual transformers and multimodal AI systems (e.g., Vision Transformers and models such as Gemini).

The practical component will provide hands-on exposure to basic data analytics and machine learning tools (e.g., open-source platforms, WEKA, Python libraries, LLAMA). Students will work on small datasets and perform tasks such as data visualization, simple predictive modeling, and experimentation with pre-trained AI models. The laboratory component will emphasize understanding concepts through experimentation rather than extensive programming.

Learning Resources:

Text Books:

1. Stuart Russell, Peter Norvig, Artificial Intelligence -A Modern Approach, Pearson, 2020, 4th Edition.
2. David L. Poole & Alan K. Mackworth, Artificial Intelligence Foundations of Computational Agents, 3rd edition, Cambridge University Press 2023
3. Tom M. Mitchell, Machine Learning, McGraw Hill.
4. Ian Goodfelllow, Yoshua Benjio, Aaron Courville, Deep Learning, The MIT Press.
5. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, Oreilly

Reference Books:

1. Kevin Knight, Elaine Rich and Shivshankar B. Nair, Artificial Intelligence, McGraw Hill, 2017, 3rd Edition.
2. Simon Hayking, “Neural Networks and Learning Machines”, Pearson, 1999
3. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.
4. C Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

EE1214 **3-0-0 (3)**

Power Systems – I

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the operation of conventional generating stations and renewable sources of electrical power.
CO-2	Apply power tariff methods and power distribution principles to practical power system applications.
CO-3	Evaluate the performance of line supporting insulators and underground cables under different operating conditions.
CO-4	Evaluate transmission line parameters and corona effects.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	1	2	3	1	1	1	2	2	3	3
CO-2	3	3	2	2	2	3	1	1	1	2	2	3	3
CO-3	3	3	3	2	2	1	1	1	1	-	1	3	3
CO-4	3	3	3	2	3	3	1	1	1	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Typical Layout of an Electrical Power System, Present Power Scenario in India.

Generation of Electric Power Conventional Sources: Hydro Power stations, Steam Power Plants, Nuclear Power Plants, Geothermal Power Plants and Gas Turbine Power Plants.

Renewable energy Sources: Solar Energy, Wind Energy, Wave energy, Tidal Energy, and Fuel Cells.

Economics of Generation: Introduction, definitions of connected load, maximum demand, demand factor, load factor, diversity factor, Load duration curve, number and size of generator units. Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff on charge to customer.

AC Distribution: Introduction, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, Selection of site and layout of substation.
Overhead Line Insulators: Introduction, types of insulators, Potential distribution over a string of suspension insulators, Methods of equalizing the potential, testing of insulators.

Insulated Cables: Introduction, need for insulation, insulating materials, Extra high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables.

Transmission line sag calculation: The catenary curve, Sag tension calculations, Supports at different levels, Stringing Chart.

Inductance and Capacitance Calculations of Transmission Lines: Line conductors, inductance and

capacitance of single phase and three phase lines with symmetrical and unsymmetrical spacing, Composite conductors-transposition, bundled conductors, and effect of earth on capacitance.

Corona and Partial Discharges: Introduction, disruptive critical voltage, corona loss, Factors affecting corona loss and methods of reducing corona loss, Disadvantages of corona, interference between power and Communication lines. Numerical problems in corona, Introduction to partial discharges, partial discharge measurement techniques, Mitigation of partial discharges.

Learning Resources:

Text Books

1. W. D. Stevenson, Elements of Power System Analysis, McGraw Hill, 2002, 4th Edition.
2. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International, 2015, 3rd Edition.
3. M.V. Deshpande, Elements of Electrical Power Station Design, Third Edition, Wheeler Pub.2001.

Reference Books:

1. C.L. Wadhwa, Electrical Power Systems, New Age International, 2016, 7th Edition.
2. H. Cotton & H. Barber, The Transmission and Distribution of Electrical Energy, ELBS,B.I.Pub.,1985, 3rd Edition.
3. D.P. Kothari and I.J. Nagrath, Power System Engineering-- Tata McGraw-Hill Pub. Co., New Delhi, 2019, 3rd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/content/storage2/courses/108105053/pdf/L-2(TB)(ET) ((EE)NPTEL).pdf
3. https://onlinecourses.nptel.ac.in/noc20_ee67/preview

EC1262 **3-0-0 (3)**

Switching Theory and Logic Design

Pre-Requisites: EC1261

Course Outcomes:

CO-1	Apply number system concepts to perform conversions used in communication and computer systems.
CO-2	Illustrate reduction of logical expressions using Boolean algebra, *k*-map and tabulation method
CO-3	Design combinational circuits for specified applications.
CO-4	Design and analyze synchronous and asynchronous sequential circuits using flip-flops
CO-5	Implement combinational logic circuits using Programmable logic devices
CO-6	Analyze analog to digital and digital-to analog signal conversion techniques.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	1	1	1	1	1	1	1	1	3	1
CO-2	2	2	1	1	1	1	1	1	1	1	1	3	1
CO-3	2	2	1	1	1	1	1	1	1	1	1	3	1
CO-4	2	2	3	1	1	1	1	1	1	1	1	3	2
CO-5	2	2		1	1	1	1	1	1	1	1	3	2
CO-6	2	2	3	1	1	1	1	1	1	1	1	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Number System and Codes: Analog versus digital, merits of digital system, number systems, base conversions, complements of numbers weighted and unweighted codes and error detecting and correcting codes, Alpha numeric code (ASCII), Error detecting and correcting codes.

Switching algebra and Switching functions: Boolean algebra, postulates, theorems and switching algebra, completely and incompletely specified switching functions, Representation of Boolean functions in sum of products form and product of sums form, minimization of Boolean functions using Karnaugh map and Quine Mc-Cluskey methods. Problem solving**.**

Combinational logic circuits: Logic gates, Logic gates operation using discrete components, Universal Logic gates, Logic design of combinational circuits: adders, Code converters**,** Comparators, multiplexers, de-multiplexers, encoders, decoders, buffers, tri-state buffers.

Logic Families: Transistor as an inverter/switch. Classification of logic families and their developments. TTL NAND gate analysis, ECL and CMOS logic family. Comparison TTL CMOS and ECL logic families.

Sequential Circuits & Applications: RS Flip flop, Clocked RS flip-flop, JK flip-flop, T-flip-flop, JK flip-flops and M/S JK flip flop, Conversion of flip-flops. Buffer Register, Controlled buffer register, Shift Registers (Left shift and Right shift register), Universal shift register: SISO, SIPO, PISO, PIPO, Ring counter and twisted

ring counter. Design of Asynchronous and Synchronous counters. Synthesis of Sequential circuits- FSM, Moore and Mealy machines.

Learning Resources:

Text Books:

1. Donald P. Leach, Malvino and Saha Digital Principles and Applications (SIE), McGraw Hill Education, 2014, 8th Edition.
2. ZviKohavi, Switching and Finite Automata Theory, McGraw-Hill, 2017, 8th Edition.

Reference Books:

1. Herbert Taub, Donald Schilling, Digital integrated electronics, McGraw-Hill, 2017.
2. Robert L.Morris and John R.Miller MH, Designing with TTL integrated circuits, 1975.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105132/.
2. https://www.tutorialspoint.com/digital_circuits/digital_circuits_flip_flops.htm

EE1216 **0-1-2 (2)**

Electrical Circuits Lab

Pre-Requisites: EE1201

Course Outcomes:

CO-1	Validate network theorems
CO-2	Evaluate the time response and frequency response characteristics of RLC series
CO-3	Determine Z, Y and ABCD parameters for a given two port network
CO-4	Simulate and analyze electrical circuits using MATLAB/ Pspice tools

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	1	2	2	1	1	2	2	1	2	3	2
CO-2	3	3	2	2	2	1	1	2	2	1	2	3	2
CO-3	3	3	2	2	2	1	1	2	2	1	2	3	2
CO-4	3	3	2	3	3	1	1	3	2	1	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Verification of Kirchhoff's laws
2. Verification of Tellegen's Theorem
3. Verification of Superposition and Thévenin's theorem
4. Verification of Maximum Power Transfer and Reciprocity theorems
5. Analysis of two port networks: Determination of Z, Y, and ABCD parameters using two port network.
6. Time response of First-order RC circuits and Second-order RLC circuits.
7. Frequency Response of Second-order RLC circuits.
8. Analysis of series and parallel coupled circuits
9. Power factor improvement and harmonic power analysis in single-phase AC circuit
10. Analysis of Single–phase series and parallel AC circuits using R-L,R-C and R -L-C elements through MATLAB/ PSPICE simulation
11. Elementary Matrix operations, simple calculations using array and vectors, creating script Files and function files, solution of circuits using mesh and loop equations, and 3- D surface plotting.

Learning Resources:

Text Books:

1. M.E.VanValken Burg, Network Analysis, Pearson Education, 2015, 3rd Edition.
2. William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw Hill, 2013, 8th Edition.
3. De Carlo, Lin, Linear circuit Analysis, Oxford University Press, 2010, 2nd Edition.

Reference Books:

1. M.L. Soni, J.C. Gupta, A course in Electrical Circuits Analysis, Dhanpat Rai & Co., 2001.
2. Alexander C.K., Sadiku M.N.O., Fundamentals of Electric Circuits, McGraw Hill Education, 2019, 6th Edition.
3. Joseph A. Edminister, Mahmood Nahvi, Electric Circuits, Schaum's series, McGraw-Hill Education, 2017, 5th Edition.
4. Stephen J. Chapman, MATLAB Programming for Engineers, CENGAGE Learning, 2020, 6th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/106/108106172/
3. https://ocw.mit.edu/search/ocwsearch.htm?q=laboratory

EC1264 **0-1-2 (2)**

IC Applications Lab

Pre-Requisites: EC1262

Course Outcomes:

CO-1	Implement analog circuit applications using OpAmp IC µA741
CO-2	Design and construct waveform generation circuits
CO-3	Verify the functionality of combinational and sequential circuit ICs.
CO-4	Design combinational and sequential circuits using Digital ICs

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	2	1	1	1	1	1	3	3	1
CO-2	3	3	3	2	2	1	1	1	1	1	3	3	1
CO-3	3	3	3	2	3	1	1	1	1	1	3	3	1
CO-4	3	3	3	2	3	1	1	1	1	1	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Study and Operation of IC testers, pulse generator and digital trainer.
2. Measurement of Op Amp parameters:
   Aim: To measure i) Input off set voltage ii) Bias current & Input Offset current iii) CMRR iv) Slew rate v) Open loop gain vi) Input impedance.
3. Op Amplifier applications
   Aim: Design and implementation of i) Adder and difference amplifier using µA741 ii) Instrumentation amplifier using LM 321
4. Op Amp Multivibrators.
   Aim: Design and implementation of monostable and astable multivibrators
5. 555 Timer as Multivibrators
   Aim: Design and implementation of Monostable and astable multivibrators
6. Linear Voltage Regulator
   Aim: Design and implementation of Voltage Regulator using 723IC
7. Combinational Logic Circuits
   Aim: Design and implementation of adders, subtractors & code converters using gate ICs
8. Characteristics of TTL NAND gate:
   Aim: To obtain (i) Sourcing (ii) Sinking (iii)Transfer characteristics of 7400
9. Adders, Multiplexers and Decoders
   Aim: Implementation of i) 4-bit Adder/ Subtractor using 7483 and 7486
   Full adder and Full subtractor using Mux 74153 and 7404
   Full adder and Full subtractor using decoder 74138

10. Study of Flip-flops

    To study functioning of 7474, 7476

    To implement a 4-bit buffer and 4-bit shift register using 7474 ICs

    To design and implement synchronous counter using 7476ICs

11. Applications of Counter ICs Aim: To implement various modes of counters using 7490, 7492 and 7493

    To implement up/down counters using 74190/74192/74193

12. Applications of Registers

    Aim: i) To implement a 4-bit shift register, self-generating ring counter and Johnson counter using 74195/7495/7498/74198.

Learning Resources:

Text Books:

1. Donald P. Leach, Malvino and Saha Digital Principles and Applications (SIE), McGraw Hill Education, 2014, 8th Edition.
2. ZviKohavi, Switching and Finite Automata Theory, McGraw-Hill, 2017, 8th Edition.

Reference Books:

1. Herbert Taub, Donald Schilling, Digital integrated electronics, McGraw-Hill, 2017.
2. Robert L.Morris and John R.Miller MH, Designing with TTL integrated circuits, 1975.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105132/.
2. https://www.tutorialspoint.com/digital_circuits/digital_circuits_flip_flops.htm

5th Semester

EE1301 **3-0-0 (3)**

Power Electronics

Pre-Requisites: None

Course Outcomes:

CO-1	Select switching devices for a given power converter.
CO-2	Evaluate the performance of phase-controlled rectifiers.
CO-3	Design DC-DC converter for a given performance
CO-4	Analyze the operation of Inverters and ac voltage controllers

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-2	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-4	3	3	3	3	3	3	1	2	1	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Concept of power electronics, scope and applications, types of power converters, power semiconductor switches and their V-I characteristics Diodes, SCR, TRIAC, power MOSFET, IGBT. Thyristor ratings and protection, methods of SCR commutation, gate drive circuits, switching and conduction losses in a generic power semiconductor device. Wide bandgap switching devices.

Phase-Controlled Rectifiers: Principles of single-phase fully-controlled converter with R, RL, and RLE load, Principles of single-phase half-controlled converter with RL and RLE load, Principles of three- phase fully-controlled converter operation with RLE load, Effect of load and source inductances, Single phase and Three phase dual converters

DC-DC Converters: Introduction, Basic principles of step-down and step-up operation, chopper classification study of Buck, Boost and Buck-Boost regulators, Continuous and Discontinuous mode of operation, Introduction to forward and flyback converters.

Inverters: Introduction, principle of operation, performance parameters, single phase bridge inverters with R, RL and RLC loads, 3-phase bridge inverters- 180 and 120 degrees mode of operation, Voltage control of single phase inverters –single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation.

A.C. Voltage Controllers: Introduction, principle of operation of single phase and three phase voltage controllers for R, R-L & R-L-E loads and its applications.

Learning Resources:

Text Books:

1. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson, 2018, 4th Edition.

2. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2002, 3rd Edition.

Reference Books:

1. P.S.Bimbhra, Power Electronics, Khanna Publishers, 2016, 6th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/101/108101038/
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://nptel.ac.in/courses/108/101/108101126/

EE1303 **3-0-2 (4)**

Microprocessors and Microcontrollers

Pre-Requisites: None

Course Outcomes:

CO-1	Develop assembly level programs of 8086 microprocessor
CO-2	Develop real-time systems on 8086-microprocessor platform using external interface peripherals
CO-3	Develop assembly level programs on the 8051 and PIC 18F-microcontroller platforms.
CO-4	Develop real-time systems on the 8051- microcontroller platform using external interface peripherals

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	3	1	1	1	1	1	1	1	2	3	1
CO-2	3	3	3	2	2	1	1	2	1	1	2	3	3
CO-3	3	3	3	3	3	3	1	3	2	2	3	3	3
CO-4	3	3	3	3	3	3	1	3	2	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Overview of the course, Functional elements of a microprocessor, overview of architecture of a general purpose microprocessor.

8086 Microprocessor: Internal Architecture of 8086, BIU and EU- Registers in of 8086- Memory segmentation- Addressing modes-register related and memory related- Instruction formats, Instruction set of 8086- Assembler directives, Tutorial- Problems on assembly language programming- Pin diagram of 8086 , Modes of operation- Timing diagrams of typical instructions- Fundamentals of I/O data transfer, Polling, Handshaking, interrupts-Steps in an interrupt process, Interrupt structure in 8086- Fundamentals of interfacing peripheral chips, Interfacing memory & I/O devices- Interfacing I/O- Programmable peripheral interface-8255, Modes of operation of 8255, Interfacing examples with 8255- Interfacing 8254 timer, Interfacing Digital to analog converters, Analog to Digital converters- Interfacing USART 8251.

8051 Microcontroller: 8051 architecture, memory organization, addressing modes & port structure, external memory access, counters and timers, Interrupts, serial communication, Microcontroller instructions -, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns. Microcontroller programming – Assembly Language Programming, timer and counter programming, Interrupt programming- Interfacing examples.

PIC Microcontrollers (PIC 18F): Introduction - Architecture – Memory organization – Assembly Language Programming and programming with Embedded C – simulation using Integrated Development Environment (IDE) - Programming of I/O ports – Addressing modes.

Bank switching – Look-up Table and Table processing – Timers and its programming – Interrupt sources- analog-to-digital converter (ADC) module-Brown-out-reset (BOR), Power- on-reset

(POR),Capture/Compare/PWM modules, USART, Master Synchronous Serial Port (MSSP) Module - Interfacing examples.

List of Lab Experiments:

1. 8086 Assembly language programs and coding of instructions.
2. Interfacing of 8255 PPI and applications with 8086Microprocessor
3. Interfacing of 8254 and serial data transfer using 8251 USART with 8086Microprocessor.
4. Programming exercises on 8051 and PIC Microcontroller
5. Interface I/O devices with and handle external interrupts using 8051microcontroller
6. PIC Serial Communication using Serial Peripheral Interface (SPI) and Interface PIC 18F45K22 Microcontroller with an LCD using PIC microcontrollers simulator (IDE)

Learning Resources:

Text Books:

1. Douglas V Hall, SSSP Rao, Microprocessors and Interfacing, McGraw Hill Education Publications, 2017, 3rdEdition.
2. Ray A.K., Bhurchandi K.M., Advanced Microprocessor and Peripherals, McGraw Hill Education Publications, 2017, 3rdEdition.

Reference Books:

1. Kenneth J Ayala, The 8051 Microcontroller, Cengage Learning Publications, 2007, 3rd Edition.
2. Barry B Brey, The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64 bit extensions, Architecture, programming and Interfacing, Pearson Education, 2009.
3. Yu-Cheng Liu, Glem A. Gibson, Microcomputer systems: The 8086/8088 Family Architecture programming and design, Pearson Education India, 2015, 2nd Edition.
4. Ajay V. Deshmukh, Microcontrollers – Theory and Applications, McGraw Hill Education Publications, 2017.
5. Nicolas K. Haddad, Microcontroller System Design using PIC18F Processors, IGI Global Publishers, 2017.
6. M. Rafiquzzaman, Microcontroller Theory and Applications with the PIC18F, Wiley, 2018, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/108/106108100/
2. https://nptel.ac.in/courses/117/104/117104072

EE1313 **3-0-0 (3)**

Power Systems – II

Pre-Requisites: EE1214

Course Outcomes:

CO-1	Analyze transmission line performance and voltage control methods.
CO-2	Apply shunt compensation techniques to control reactive power
CO-3	Evaluate transmission line performance using per unit quantities and travelling wave concepts.
CO-4	Determine the fault currents for symmetrical and unbalanced faults

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	1	1	2	1	3	2
CO-2	3	3	3	3	3	1	1	1	1	2	1	3	1
CO-3	3	3	3	3	3	1	1	1	1	2	1	3	1
CO-4	3	3	3	3	3	1	1	1	1	2	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Performance of Lines: Representation of lines, short transmission lines, medium length lines, nominal T and PI-representations, long transmission lines. Distributed model, The equivalent circuit representation of a long Line, A, B, C, D constants, Ferranti Effect, Power flow through a transmission line, receiving end power circle diagram.

Voltage Control: Introduction methods of voltage control, shunt and series capacitors / Inductors, tap changing transformers, synchronous phase-modifiers.

Compensation in Power Systems: Introduction- Concepts of Load compensation Load ability characteristics of overhead lines uncompensated transmission line Symmetrical line Radial line with asynchronous load Compensation of lines.

Per Unit Representation of Power Systems: The one-line diagram, impedance and reactance diagrams, per unit quantities, changing the base of per unit quantities, advantages of per unit system.

Travelling Waves on Transmission Lines: Production of traveling waves, open circuited line, short circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at T-junction line terminated through a capacitance, capacitor connection at a T-junction, Attenuation of travelling waves.

Symmetrical Components: Significance of positive, negative and zero sequence components, Average 3-phase power in terms of symmetrical components, sequence impedances and sequence networks.

Fault Calculations: Fault calculations, sequence network equations, single line to ground fault, line to line fault, double line to ground fault, three phase fault, faults on power systems, and faults with fault impedance, reactors and their location, short circuit capacity of a bus.

Learning Resources:

Text Books

1. John J.Grainger, W.D. Stevenson: Power System Analysis, McGrawHill International (Indian Edition) 2017.
2. C.L. Wadhwa: Electrical Power Systems New Age International Pub. Co., 2016, 7th Edition.

Reference Books:

1. Hadi Saadat: Power System Analysis Tata Mc Graw Hill Pub.Co., 2011, 4th Edition.
2. D.P. Kothari and I.J. Nagrath, Power System Engineering-- Tata McGraw-Hill Pub. Co., New Delhi, 2019, 3rd Edition.
3. W.D. Stevenson: Elements of Power system Analysis, McGraw Hill International, 2015, 4th Edition.
4. D. Das, Electrical Power Systems New Age International Pub. Co., 2016, 3th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/courses/108/107/108107112/

EE1315 **3-0-0 (3)**

Digital Signal Processing

Pre-Requisites: None

Course Outcomes:

CO-1	Apply the sampling theorem and its importance in signal conversion.
CO-2	Analyze the frequency response of discrete systems using Fourier transforms
CO-3	Synthesis and realize the Different Digital FIR and IIR filters
CO-4	Apply TMS320LF2407 digital signal processor for filter applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-2	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-4	3	3	3	3	3	3	1	2	1	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Signals and Systems: Introduction to digital systems, Definition of signal and system, Shannon's sampling theorem, Types of Discrete-Time signals, Aliasing Phenomena, Impulse Response, Linear Time Invariant systems, Linear convolution, Difference Equations, Solving Difference equations.

Fourier analysis and Z-Transform: Definition of Continuous Time & Discrete Time Fourier Series and Fourier Transform (CTFS, CTFT, DTFS, DTFT), DTFT Properties and its application. Definition of two-sided Z-transform, Properties of Z-Transform, Convolution using Z- transform, One-sided Z-Transform, Transform Analysis of Systems, System Function, Systems with Linear Phase.

Synthesis of Digital Filters and its realization: Basics of Digital Filters: Low pass, High pass, Band pass, Band Stop, Finite Impulse response (FIR) filter- Synthesis of FIR Filter using DTFT approach-Infinite impulse response (IIR) filter; Butterworth filter, Chebyshev filter, Bilinear Transformation, Realization of Digital Filters: Direct Systems, Indirect Systems, Cascade Structure, Transposed/Lattice Structures, Parallel structures for IIR and FIR systems

Fast Fourier Transform (FFT): Definition of Discrete Fourier and Fast Fourier Transforms, DFT properties, Sampling the DTFT, Linear convolution using DFT, Radix-2 FFT algorithms, decimation in time, decimation in frequency.

TMS320LF2407 Digital Signal Processor: Architecture, addressing modes, Instruction set and simple applications, Arithmetic operations, Circular Convolution.

Learning Resources:

Text Books:

1. J.G. Proakis, D.K Manolakis, Digital signal processing: Principles, algorithms and applications, Pearson Education, 2020, 4th Edition.
2. T. Holton, Digital Signal Processing: Principles and Applications, Cambridge University Press, 2021, 1st Edition.

Reference Books:

1 S.K. Mitra, Digital signal processing: A Computer Based Approach, McGraw Hill Education,
2 2013, 4th Edition.
3 Alan V Oppenheim and Ronald W. Schafer, Digital signal processing, Pearson Education India, 2015, 1st Edition.
4 S Salivahanan, Ganapriya, Digital signal processing, Tata McGraw Hill, 2019, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106151/
2. https://nptel.ac.in/courses/108/105/108105055/

MS1369 **3-0-0 (3)**

Principles and Practices of Management for Electrical Engineers

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the fundamental concepts, principles, and functions of management in engineering and technology-oriented organizations.
CO-2	Develop planning, organizing, staffing, and decision-making approaches for managerial problem situations in organizations.
CO-3	Apply leadership, communication, and motivation practices for effective management of individuals and teams in organizations.
CO-4	Examine managerial control processes and productivity improvement practices in organizations
CO-5	Analyze contemporary management practices and design managerial applications in electrical engineering domain-specific organizational contexts.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	–	–	–	–	–	–	–	3	–	3	3	–	–
CO-2	–	–	–	–	–	–	–	2	–	3	3	–	–
CO-3	–	–	–	–	–	–	–	1	–	3	3	–	–
CO-4	–	–	–	–	–	–	–	1	–	2	2	–	–
CO-5	–	–	–	–	–	–	–	1	–	1	2	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Evolution of management thought; Organizations and types; Business functions and their roles; Levels of management, Functions of management, Managerial roles and skills; Ethics in management.

Planning, Organizing & Staffing: Planning process, Types of plans, Objectives, Strategies, Policies; Decision-making; Organizational structure, Departmentation, Delegation of authority, Centralization and decentralization; Organizational culture; Staffing - Human resource planning, Recruitment and Selection, Training and development, Performance and reward Management.

Leading: Leadership - Leadership styles; Approaches to leadership; Contemporary leadership in organizations; Communication-Process of communication; Types of communication, Barriers to communication, Effective communication in organizations; Motivation - Importance of motivation, Key theories of motivation; Application of motivation in managerial practice.

Controlling: Importance and process of controlling, Control techniques; Types of control; Performance and productivity control -Performance standards; KPI-based control; Quality and managerial control - Benchmarking; Continuous improvement, Management reporting; Control in modern organizations.

Contemporary Management Practices: Digital and Data-driven management; Modern organizational practices -Agile management; Lean management; Sustainability management; Management Applications in Electrical Engineering Industry with case study orientation.

Learning Resources:

Text Books:

1. Stephen P. Robbins, Mary A. Coulter, Lori Long, Management, Pearson, 2025, 16th Edition.
2. Harold Koontz, Heinz Weihrich, Mark V. Cannice, Essentials of Management: An International, Innovation and Leadership Perspective, McGraw Hill, 2020, 11th Edition.

Reference Books:

1. Richard L. Daft, Management, Cengage Learning, 2023, 15th Edition.
2. Peter F. Drucker, The Practice of Management, Harper Business, Reprint Edition, 2006.
3. Laurie J. Mullins, Management and Organisational Behaviour, Pearson Education, 2023, 13th Edition.
4. Heinz Weihrich, Mark V. Cannice, Harold Koontz, Management: A Global, Innovative and Entrepreneurial Perspective, McGraw Hill, 2020, 16th Edition.
5. Ricky W. Griffin, Management, Cengage Learning, 2021, 14th Edition.

Other Suggested Readings:

1. NPTEL, Principles of Management, offered by IITs and IISc, available through SWAYAM.
2. SWAYAM, Management and Leadership Courses, Government of India MOOC Platform.
3. Coursera, Principles of Management, offered by leading global universities.
4. edX, Management and Leadership Programs, offered by international universities and institutions.
5. Harvard Business Publishing Education, Case Studies and Learning Resources on Leadership, Innovation, and Organizational Management.
6. MIT Sloan Management Review, Articles and Case Studies on Contemporary Management Practices, Digital Transformation, and Innovation Management.

EE1309 **0-1-2 (2)**

Control Systems Lab

Pre-Requisites: EE1206

Course Outcomes:

CO-1	Implement PI/PID controllers for DC servo motor based position control applications.
CO-2	Perform the time domain and frequency domain analysis of the given linear systems
CO-3	Design and implement the State feedback controller for unstable mechatronic system
CO-4	Analyze and design the controllers using MATLAB for the given linear system

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	2	3	1	1	2	1	1	2	3	2
CO-2	3	3	2	2	2	1	1	2	1	1	2	3	2
CO-3	3	3	3	2	3	1	1	2	1	1	3	3	3
CO-4	3	3	3	2	3	1	1	3	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Time domain analysis of first and second order systems (Hardware)
2. Frequency-response characteristics of second order system (Hardware)
3. Performance assessment of P, PI & PID controller for different linear systems
4. Implementation of the lag and lead compensator networks for linear system
5. Design of Position control system for DC Servo motor using PV controller (Hardware)
6. Pole placement approach to control the position of Industrial plant Emulator hardware system.
7. Tuning of PI/PID Controller for Thermal hardware system.
8. Control system design for unstable Magnetic levitation system (Hardware).
9. Synthesis of Disturbance rejection controller for Rotary flexible link system (Hardware)
10. Stabilization of Rotary Inverted Pendulum using state feedback controller (Hardware)
11. Stability analysis and controller design for linear systems using MATLAB

Learning Resources:

Text Books:

1. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015, 13th Edition.
2. B.C.Kuo: Automatic Control Systems, Wiley, 2014, 9th Edition.

EE1311 **0-1-2 (2)**

Electrical Machines Lab

Pre-Requisites: EE1202

Course Outcomes:

CO-1	Select apparatus based on the ratings of DC machines, transformers, induction motors, and synchronous machines.
CO-2	Determine equivalent circuit parameters and evaluate the performance of transformers, induction motors, and synchronous motors.
CO-3	Predetermine the performance of DC machines, transformers, and induction motors and verify with loading tests.
CO-4	Determine the V and inverted-V curves of synchronous motors.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	2	2	1	2	3	1	2	3	1
CO-2	3	2	1	2	1	2	1	2	3	1	2	3	1
CO-3	3	3	2	1	2	2	1	2	3	1	2	3	1
CO-4	3	2	3	1	1	2	1	2	3	1	2	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Speed control of DC shunt motor using armature voltage and field current control methods.
2. (a) Determination of performance characteristics of a DC Shunt motor using brake test.
   (b) Predetermination of efficiency of a DC shunt motor using Swinburne's test.
3. Hopkinson test on DC shunt machines.
4. (a) Predetermination of the efficiency of a single-phase transformer using open circuit (OC) and short circuit (SC) tests.
   (b) Determination of efficiency and regulation of a single-phase transformer using a load test.
5. Determination of the efficiency of a transformer using Sumpner's test.
6. Separation of no-load losses of a single-phase transformer.
7. (a) Predetermination of the performance of a 3-phase induction motor using the Equivalent Circuit and Circle diagram
   (b) Brake test on a 3-phase induction motor
8. Predetermination of the regulation of a 3-phase alternator by the E.M.F. method and using Slip Test
9. Determination of 'V' and inverted V curves of a 3-phase synchronous motor
10. Demonstration of different phase groups, study of voltage, current, and flux harmonics, Three-

phase to 6-phase, three-phase to 12-phase conversion by using a three-phase multi-tapping transformer

11. Parallel operation of a three-phase transformer

Learning Resources:

Text Books:

1. D.P. Kothari, B.S. Umre, Laboratory manual for Electrical Machines, Wiley Publishers, 2nd Edition, 2020.
2. D.K. Chaturvedi, Electrical Machines Lab Manual with MATLAB, Laxmi Publications, 1st Edition, 2020.

EE1381 **1-0-0 (1)**

Fractal Course – I

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Electrical Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content.
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	-	-	-	-	-	-	-	-	2	2
CO-2	-	-	-	2	2	3	-	-	-	-	-	3	2
CO-3	-	-	3	2	2	-	-	-	-	-	-	3	2
CO-4	-	-	-	-	-	-	-	1	3	-	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Electrical engineering field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Electrical Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

6th Semester

EE1312 **3-0-0 (3)**

Electric Drives

Pre-Requisites: EE1202

Course Outcomes:

CO-1	Analyze drive mechanisms and energy conservation methods.
CO-2	Apply power electronic converters to control the speed of DC motors and induction motors.
CO-3	Evaluate the motor and power converter for a specific application.
CO-4	Develop closed loop control strategies of drives

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	2	3	3	2	1	1	2	3	3	3
CO-2	3	3	3	3	3	3	2	3	1	2	3	3	3
CO-3	3	3	3	3	3	3	2	3	1	2	3	3	3
CO-4	3	3	3	3	3	3	2	3	1	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to electric drives: Advantages of Electric drives, Parts of Electrical Drives, Electric Motors, Power Modulators, Sources, Choice of Electric Drives and selection of drives for various applications.

Dynamics of electrical drives: Fundamental torque equation, components of load torque, speed-torque characteristics of loads, Nature and classification of load torques, speed-torque convention & multi-quadrant operation. Equivalent values of drive parameters, loads with rotational motion, loads with translational motion, measurement of moment of inertia. Steady state stability, dynamic stability, load equalization. Basic principles of closed-loop control.

DC Motor Drives: Speed control of DC motors using single-phase and three-phase fully controlled and half controlled rectifiers in continuous and discontinuous mode of operation. Single quadrant, two quadrant and four quadrant chopper controlled drives in continuous and discontinuous mode of operation.

Induction Motor Drives: Speed control of cage induction motors with constant V/f control for open-loop and closed-loop (slip speed compensation) schemes by voltage source inverter (VSI), slip power recovery scheme, static Scherbius and Krammer methods, current source inverter (CSI)-fed induction motor drive (stator current control), comparison of VSI and CSI-fed induction motor drives, and AC and DC dynamic braking methods.

Synchronous Motor Drives: Speed control of Permanent Magnet Synchronous Motor (PMSM) drive with variable voltage and frequency control schemes, speed control of brushless direct current motor (BLDC) drives by current control using hall effect sensors and its applications.

Learning Resources:

Text Books:

1. G.K. Dubey, Fundamentals of Electric Drives – Narosa Publishers, 2010, 2nd Edition.
2. S B Dewan, G.R.Selmon & A. Straughen, Power Semiconductor Drives, Wiley India Pvt. Ltd, 2009.
3. Vedam Subramanyam, Electric Drives Concept and Application, McGraw Hill Education, 2017, 2nd Edition.

Reference Books:

1. Werner Leonhard, Control of Electric Drives, Springer international edition, 2006.
2. Mohammed Fazlur Rahman, Sanjeet K. Dwivedi, Modeling, Simulation and Control of Electrical Drives, Institution of Engineering and Technology, 2019.
3. Rama Krishnan, Electric motor drives: modeling, analysis, and control, Pearson Education, 2015, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104140/

EE1314 **3-0-0 (3)**

Power System Operation and Control

Pre-Requisites: EE1313

Course Outcomes:

CO-1	Evaluate load flow, economic operation, and load frequency control of power systems.
CO-2	Analyze the functions of Energy Management System (EMS).
CO-3	Determine the stability of power systems.
CO-4	Analyze power system deregulation and smart grid technologies.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	2	1	3	1	2	2	3	2
CO-2	3	3	3	2	3	2	1	1	1	3	2	3	2
CO-3	3	3	3	3	3	3	1	2	1	1	2	3	2
CO-4	3	3	3	1	3	3	1	1	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Load Flow Studies: Introduction, Bus classification -Nodal admittance matrix - Load flow equations - Iterative methods - Gauss and Gauss Seidel Methods, Newton-Raphson Method- Fast Decoupled method - Merits and demerits of the above methods - System data for load flow study. Distribution Load Flow Analysis, Backward-forward load flow, direct approach based load flow analysis.

Control of Real-Power: Effect of synchronous machine excitation-Power angle of a synchronous machine-Specification of bus voltages, control by transformers.

Economic Operation of Power Systems: Distribution of load between units within a plant Transmission loss as a function of plant generation, Calculation of loss coefficients - Distribution of load between plants.

Load Frequency Control: Introduction, load frequency problem-Megawatt frequency (or P-f control channel, MVAR- voltages (or Q-V) control channel-Dynamic interaction between P-f and Q-V loops. Mathematical model of speed-governing system-Turbine models, division of power system into control areas, P-f control of single control area (the uncontrolled and controlled cases)-P-f control of two area systems (the uncontrolled cases and controlled cases)

Power System Stability: The stability problem- Steady state stability, transient stability and Dynamic stability-Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step-by-step solution of swing equation-Factors affecting transient stability, Methods to improve steady state and Transient stability, Introduction to voltage stability

Power System Deregulation (Qualitative Treatment Only): Introduction - Power system restructuring models- responsibilities and functions of independent system operator (ISO), Ancillary Services.

Learning Resources:

Text Books:

1. C.L. Wadhwa, Electrical Power Systems, 3rd Edition, New Age International Publishing Co., 2001.
2. D.P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Education Private Limited, 2011, 4th Edition.

Reference Books:

1 Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, Power System Generation, Operation and Control, John Wiley and Sons, 2013, 3rd Edition.
2 Elgerd. O.I, Electric Energy System Theory – an Introduction, Tata McGraw Hill, New Delhi, 2013.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104052/
2. https://nptel.ac.in/courses/108/105/108105133/
3. https://nptel.ac.in/courses/108/106/108106026/
4. https://nptel.ac.in/courses/108/102/108102080/

EE1306 **0-1-4 (3)**

Product Development

Pre-Requisites: None

Course Outcomes:

CO-1	Develop electric equivalent model for physical systems.
CO-2	Express Product Design Ideas such as MATLAB/Simulink and PSpice
CO-3	Evaluate the performance of the model
CO-4	Develop and evaluate prototype of the product
CO-5	Improve the product based on testing with user feedback

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	3	3	3	2	3	3	2	3	3	2
CO-2	2	2	2	3	3	3	2	3	3	2	3	3	2
CO-3	2	2	2	3	3	3	2	3	3	2	3	3	2
CO-4	2	2	2	3	3	3	2	3	3	2	3	3	2
CO-5	2	2	2	3	3	3	2	3	3	2	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Design Thinking process for Product Development: Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

Project Selection: Identification of the problem through empathy, formulate and ideate to solve the problem.

Product Development

- Identification of a particular solution out of different possible solutions from the aspects of performance, cost, and manufacturability.
- Simulation studies of the proposed method/solution for performance evaluation using MATLAB/SIMULINK, PSpice etc.
- Hardware development and testing.

Iterative improvement of the product & Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

IPR: Different forms of innovations emanating from the human mind and their protection using different tools of IPR, Basic introduction to Patents, Trademarks, Copyright, Industrial Designs Registrations, Geographical Indications Trade Secrets. Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights.

Learning Resources:

Text Books:

1. The design studio method: creative problem solving with UX sketching, Sullivan, Brian, Focal Press, 2016.
2. Autodesk Fusion 360 Black Book, Verma G., CADACAMCAE Works, 2021, 2nd Edition.
3. Class Junghans and Adam Levy, Intellectual Property Management: A guide for Scientists, Engineers, Financers and Managers, Willey (2006)

Other Suggested Readings:

1. Self-Paced Tutorials: https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

EE1310 **0-1-2 (2)**

Electrical Simulation Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Simulate and analyse electrical and power electronic circuits.
CO-2	Model, simulate and analyze the performance of DC Machines
CO-3	Analyze performance of feedback and load frequency control systems
CO-4	Evaluate the performance of transmission lines

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	3	2	1	3	3	2
CO-2	3	3	3	3	3	1	1	3	2	1	3	3	2
CO-3	3	3	3	3	3	1	1	3	2	1	3	3	2
CO-4	3	3	3	3	3	1	1	3	2	1	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Solution of first and second order differential equations using RK-4th order method.
2. Simulation of half wave and full wave bridge rectifiers with R-L, R-C and R-L-C Loads using MATLAB
3. Performance evaluation of medium and long transmission lines using MATLAB
4. Symmetrical component analysis using MATLAB
5. DC Motor Speed control using MATLAB/Simulink
6. Design and analyses the performance of feedback control system
7. Simulate and tune parameters of a PID controller for a Type 2 system
8. Load frequency control of single area and two area power system with MATLAB /Simulink
9. Performance of FC-TCR compensator using PSCAD/ EMTDC/MATLAB
10. Permanent Magnet DC motor simulation using MATLAB /Simulink
11. Transient stability studies of SMIB system using equal area criterion using MATLAB.
12. Analysis of 5-Bus system using Power World Simulator
13. Simulation and Analysis of Faults using PSCAD
14. Small signal stability studies of SMIB system using Phillips Hefron model
15. Speed Control of Induction Motor using V/f method.

Learning Resources:

Text Books:

1. James C. Squire and Julie Phillips Brown, Programming for Electrical Engineers: MATLAB and Spice, Academic Press, 2021

EE1316 **0-1-2 (2)**

Digital Signal Processing Lab

Pre-Requisites: EE1315

Course Outcomes:

CO-1	Analyze and synthesis FIR type digital filter
CO-2	Design the IIR digital filter for noisy signal
CO-3	Develop software in assembly language for TMS320LF2407A
CO-4	Verify the sampling theorem and Implement the Digital filter using TMS320LF2407A

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	2	3	3	2	2	2	3	3	2	2
CO-2	3	2	3	3	3	3	2	3	3	3	3	3	2
CO-3	3	2	3	3	3	3	2	3	3	3	3	3	2
CO-4	3	2	3	3	3	3	2	3	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Generation of various digital signals, sampling theorem and its effect.
2. Elementary FIR type digital filters and its filtering characteristics.
3. Windowing technique based FIR Digital filter design.
4. Design of Infinite Impulse Response (IIR) filter
5. Familiarization of IDE and code-composer studio for arithmetic and logical operations.
6. Basic assembly language programming of TMS320LF2407A processor.
7. Demonstration of aliasing effect using TMS320LF2407A processor.
8. Analog to Digital conversion (ADC) using TMS320LF2407A processor.
9. Implementation of Digital Filters using TMS320LF2407A processor.
10. TMS320F28069 processor based implementation of Digital Filters.

Learning Resources:

Reference Books:

1. V.K.Ingle, J.G.Proakis, Digital Signal Processing Using MATLAB, CENGAGE Learning, 2012, 3rd Edition.
2. Hamid A. Toliyat, Steven G. Campbell, DSP Based Electromechanical Motion Control, CRC Press, 2019, 1st Edition.

EE1382 **1-0-0 (1)**

Fractal Course – II

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Electrical Engineering.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content.
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	-	-	-	-	-	-	-	-	2	2
CO-2	-	-	-	2	2	3	-	-	-	-	-	3	2
CO-3	-	-	3	2	2	-	-	-	-	-	-	3	2
CO-4	-	-	-	-	-	-	-	1	3	-	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Electrical engineering field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Electrical Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts

7th Semester

EE1407 **3-0-0 (3)**

Power System Protection

Pre-Requisites: EE1313

Course Outcomes:

CO-1	Evaluate electromagnetic, static and microprocessor based relays
CO-2	Design protection schemes for power systems.
CO-3	Select relay settings for overcurrent and distance relays.
CO-4	Analyze quenching mechanisms used in air, oil, SF_6 and vacuum circuit breakers

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	2	3	2	1	2	1	2	1	3	3
CO-2	3	3	3	3	3	2	1	2	1	3	1	3	3
CO-3	3	3	2	2	2	2	1	2	1	2	1	2	1
CO-4	3	3	2	2	2	2	1	2	1	2	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Need for power system protection, effects of faults, Measures to reduce the impact of faults,

Fuses: Introduction, fuse characteristics, types of fuses, application of HRC fuses, discrimination

Overvoltage Protection and Insulation Coordination: Over voltage due to arcing ground and Peterson coil, Lightning Arresters, Insulation Coordination

Protective Relays: Evolution of protective relays, zones of protection, primary and backup protection, essential qualities of protection, classification of protective relays and schemes, current transformers, potential transformers, basic relay terminology.

Operating Principles of Protective Relays: Electromagnetic relays, thermal relays, static relays, Amplitude and Phase comparators, Duality between AC and PC, Static amplitude comparator, integrating and instantaneous comparators, static phase comparators, coincidence type of phase comparator, introduction to microprocessor based protective relays.

Over-current Protection: Time-current characteristics, current setting, over current protective schemes, directional relay, protection of parallel feeders, protection of ring mains, Phase fault and earth fault protection, Combined earth fault and phase fault protective scheme, Directional earth fault relay.

Distance Protection: Impedance relay, reactance relay, MHO relay, input quantities for various types of distance relays, Effect of arc resistance, Effect of power swings, effect of line length and source impedance on the performance of distance relays, selection of distance relays, MHO relay with blinders, Reduction of measuring units, switched distance schemes.

Pilot Relaying Schemes: Wire Pilot protection, Carrier current protection. AC Machines and Bus Zone Protection: Protection of Generators, Protection of transformers, Bus-zone protection, frame leakage protection.

Static Relays: Static over current relays, static directional relay, static differential relay, static distance relays, and Multi input comparators, concept of Quadrilateral and Elliptical relay characteristics. Microprocessor Based Relays: Over current relays, directional relays, distance relays.

Circuit Breakers: Introduction, arcing in circuit breakers, arc interruption theories, re-striking and recovery voltage, resistance switching, current chopping, interruption of capacitive current, oil circuit breaker, air blast circuit breakers, SF6 circuit breaker, operating mechanism, selection of circuit breakers, high voltage DC breakers, ratings of circuit breakers, testing of circuit breakers.

Learning Resources:

Text Books:

1. Badri ram and D.N. Vishwakarma, Power System Protection and Switchgear, TMH, 2001.
2. L. Singh, Digital Protection: Protective relaying from Electromechanical to Microprocessors New Age International,1994.
3. U.A. Bakshi, M. V. Bakshi, Switchgear and Protection, Technical Publications, 2009.

Reference Books:

1. C. Russel Mason, The art and science of protective relaying, Wiley Eastern,1995

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/101/108101039/
2. https://nptel.ac.in/courses/108/105/108105167/
3. https://nptel.ac.in/courses/108/107/108107167/

EE1403 **0-1-2 (2)**

Power Electronics & Drives Lab

Pre-Requisites: EE1301 & EE1312

Course Outcomes:

CO-1	Control rectifiers, DC-DC converters, AC voltage controllers and inverter circuits.
CO-2	Evaluate performance indices for power converters.
CO-3	Design control and drive circuitry for power converters.
CO-4	Implement control strategies for electric drives.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	1	2	1	1	3	3	1	1	3	1
CO-2	3	3	2	1	2	1	1	3	3	1	1	3	1
CO-3	3	3	2	2	2	3	1	3	3	2	2	3	3
CO-4	3	3	3	3	3	3	1	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Study of Static Characteristics of SCR, MOSFET & IGBT.
2. Study of single-phase half-controlled, Fully-Controlled bridge converter with R, RL and RLE load.
3. Study of three-phase half-controlled and Fully- Controlled bridge converter with R, RL and RLE load.
4. Study of single-phase dual converter with *RL* loads.
5. Study of AC voltage controller using TRIAC with *R* and *RL* load.
6. Analysis of steady-state characteristics of DC-DC Buck converter with Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM).
7. Analysis of steady-state characteristics of DC-DC Boost converter with Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM).
8. Analysis of steady-state characteristics of DC-DC Buck-Boost converter with Continuous Current Mode (CCM) and Discontinuous Current Mode (DCM).
9. Speed control of DC motor by armature voltage control scheme using four-quadrant chopper.
10. Analysis of frequency spectrum of unipolar and bi-polar Pulse width modulation (PWM) based single-phase inverter using dSPACE-1104 controller.
11. Analysis of frequency spectrum for 3-Phase Pulse width modulation (PWM) & non- Pulse width modulation (PWM) inverter using dSPACE -1104 controller.
12. Open loop speed control scheme of induction motor by constant V/f using dSPACE-1104 controller.

13. Closed loop speed control scheme (slip speed compensation) of induction motor by constant *V/f* using dSPACE-1104 controller.

Learning Resources:

Text Books:

1. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson, 2018, 4th Edition.
2. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2002, 3rd Edition.
3. G.K. Dubey: Fundamentals of Electric Drives –Narosa Publishers, 2007, 2nd Edition.
4. S.B. Dewan, G.R. Slemom, A. Straughen: Power semiconductor drives, John Wiley & Sons.
5. Vedam Subramanyam: Electric Drives Concepts & Applications –Tata McGraw Hill Edn. Pvt.Ltd, 2011, 2nd Edition.

Reference Books:

1. Werner Leonhard, Control of Electric Drives, Springer international edition, 2001.
2. Nisit K. De and Swapan K. Dutta, Electric Machines and Electric Drives, PHI learning Pvt. Ltd, 2011.
3. V. Subrahmanyam, Thyristor Control of Electric Drives, Tata McGraw Hill Edn. Pvt.Ltd, 2010.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/101/108101038/
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://nptel.ac.in/courses/108/101/108101126/
4. https://nptel.ac.in/courses/108/104/108104140/

EE1409 **0-1-2 (2)**

Power Systems Lab

Pre-Requisites: EE1407

Course Outcomes:

CO-1	Evaluate the Reactive power control in a Tap Changing Transformer & long transmission lines.
CO-2	Determine the sequence components of unbalanced voltages and fault currents of Power system elements.
CO-3	Investigate the characteristics of PV arrays under varying irradiation and temperature.
CO-4	Evaluate the breakdown strength of Electrical Insulation and design ground grid for Substation.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	1	2	1	1	3	3	1	1	3	1
CO-2	3	3	2	1	2	1	1	3	3	1	1	3	1
CO-3	3	3	2	2	2	3	1	3	3	2	2	3	3
CO-4	3	3	3	3	3	3	1	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Reactive Power Control Using Tap Changing Transformer
2. Regulation, efficiency characteristics of artificial transmission line and Reactive Power compensation
3. Determination of Sequence Reactance's and fault studies of Power System Elements (Alternator & 3- Φ Transformer)
4. Analysis of unbalanced voltages using Symmetrical Component Analyzer
5. Determination of String efficiency of simulated string of insulators & calibration of sphere gap arrangement for HV voltage measurement using 100kV Test Transformer
6. Characteristics of PV Array
7. Grounding grid design for a two layers soil model using AUTOGRID PRO software simulation
8. Tracking and Treeing test on surface of solid insulation
9. Generation of different Impulse waveforms
10. Testing of Electromechanical Under Voltage Relay and plot the graph between Operating Time Vs percentage of plug Setting voltage.
11. Testing of Electromechanical Over Voltage Relay and plot the graph between Trip Time Vs Plug Setting Multiplier (PSM).

12. Testing the operating characteristics of microprocessor based over current relay and plotting a graph between trip time Vs Plug Setting Multiplier (PSM).
13. Measurement of partial discharges in solid and liquid dielectrics.

Learning Resources:

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc20_ee67/preview

EE1489 **Seminar and Technical Writing** **0-0-0 (2)**

Pre-Requisites: None

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	-	2	-	-	3	-	2	3	-	3	2	2
CO-2	2	-	2	-	-	3	-	2	3	-	3	3	2
CO-3	2	-	2	-	-	3	-	2	3	-	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures / invited talks / Seminar / Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

EE1491 Short Term Industrial / EPICS / Research Experience 0-0-0 (2)

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	-	-	-	-	-	3	2	2
CO-2	2	2	2	2	2	-	3	3	-	3	3	3	2
CO-3	-	-	-	-	-	3	-	-	-	-	3	3	2
CO-4	-	-	-	-	-	-	-	-	3	-	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Relevance of the area of work	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Performance of the Task	
III	Crucial learnings from the work	
IV	Report Preparation	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

EE1495 **0-0-0 (2)**

Minor Project

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world projects
CO-2	Plan and monitor project tasks individually or as a team
CO-3	Demonstrate practical experience in project execution
CO-4	Communicate project findings clearly through reports and presentations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	-	-	2	1	1	3	2	2
CO-2	2	2	2	2	2	-	-	3	2	3	3	3	2
CO-3	2	2	2	2	2	-	-	3	2	3	3	3	2
CO-4	1	1	1	1	1	-	-	3	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Identification of Problem Domain	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Study of Existing Systems and establishing clear objectives	
III	Planning of project and work distribution within the team	
IV	Proper Documentation and Technical Writing	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X	X	
IV				X
V				X

8th Semester

EE1498 **0-0-0 (6)**

Major Project

Pre-Requisites: None

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	-	-	2	1	1	3	1	1	2	2	2
CO-2	2	2	-	-	1	2	1	2	2	-	3	3	3
CO-3	2	2	3	3	3	2	2	2	1	3	2	3	3
CO-4	2	2	-	3	3	-	-	2	2	-	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	Weightage
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded 'F' grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Selection of Topic	10
II	Literature Survey	10
III	Objectives and Solution Methodology	10
IV	Performance of the Task and clarity on the work	30
V	Report Preparation	20
VI	Presentation and Response to questions	20

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Refer to the B.Tech. – Regulations for any further information regarding mid-term review, end semester evaluation, template for report preparation and plagiarism guidelines etc.

Program Electives

EE1322 **3-0-0 (3)**

Design of Electrical Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Develop mathematical models of electrical, magnetic, and thermal circuits of electrical machines.
CO-2	Analyze design aspects of rotating DC machines.
CO-3	Analyze optimum design procedure of transformers.
CO-4	Select suitable layout and rating of sub-station components.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	3	2	2	1	1	1	1	1	1	3	2
CO-2	3	3	3	2	2	2	1	1	1	1	1	3	2
CO-3	3	3	3	2	2	2	1	1	1	1	1	3	2
CO-4	3	3	3	2	3	2	1	2	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Magnetic Circuit: Magnetic leakage calculations, Effect of leakage flux, Slot leakage, tooth top leakage, Zig-Zag Leakage, over hang leakage. Leakage with fractional pitch windings, effect of saturation and load on leakage coefficient. Leakage reactance calculations of polyphase machines.

Electric Circuit: Design of DC-machine windings: Simplex, Duplex and Multiplex Lap and Wave Windings, Design of AC machine windings: Concentric windings, Mush windings, Double layer integral slot and fractional slot lap and wave windings.

Design of Rotating Machines: Relation between rating and dimensions of rotating machines, Choice of specific electric and magnetic loadings, Separation of main dimensions (D and L) for DC machines, Induction Machines and Synchronous Machines. Output equation for DC- machine, Selection of No. of Poles, No. of armature slots, Length of air-gap and field pole design. Stator design for induction and synchronous machine, design of rotor slots end rings and wound rotor for induction machine. Design of rotor for salient and non-salient pole synchronous machines.

Design of Transformers: Output equation, Choice of flux density, Design of rectangular, square and stepped cores, and Design for minimum cost and minimum losses. Design of windings. Cooling of transformers, Design of transformer tanks and cooling ducts.

Design of Substations: Layouts for indoor and out-door substations for single feeder, double feeder and multi-feeder. Design of Power Capacitors. Selection and design of circuit breakers and Isolators. Basic design aspects of gas insulated substations (GIS), Design of substation Grounding.

Learning Resources:

Text Books:

1. A. K. Sawhney A course in Electrical Machine Design, Dhanpat Rai & Co., New Delhi. 2013, 6th Edition.
2. Juha Pyrhonen, Tapani Jokinen, Valeria Hrabovcova, Design of Rotating Electrical Machines, John Wiley & Sons, New Delhi, 2013.
3. M.K. Giridharan, Electrical Systems Design, I K International, 2015.

Reference Books:

1. Alexander Gray, Electrical Machine Design, McGraw Hill, New York, 2008.
2. M. G. Say, Performance and Design of AC Machines, Pitman Pub, 2002.
3. E Clayton & N. N. Hancook, Performance and design of DC machines, CBSPub., 1998, 3rd Edition.
4. H. Partab, Arts and Science of Utilization of Electrical Energy, Dhanpat Rai & Co., 2017.

EE1324 **3-0-0 (3)**

AI Techniques in Electrical Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the concepts of Artificial Neural Networks, Fuzzy Logic, and Genetic Algorithms.
CO-2	Distinguish between knowledge-based systems and algorithmic based systems
CO-3	Evaluate the operation and performance of fuzzy controllers and genetic algorithms.
CO-4	Apply soft computing techniques for real world problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	2	3	3	1	3	3	1	2	1	3
CO-2	3	3	3	3	2	3	3	1	2	3	2	3	1
CO-3	2	3	2	2	3	2	2	2	2	2	2	2	2
CO-4	2	2	2	2	3	1	1	1	1	1	2	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Artificial Neural Networks: Introduction, Models of Neuron Network, Architectures – Knowledge representation, Artificial Intelligence and Neural networks–Learning process, Error correction learning – Hebbian learning –Competitive learning – Boltzman learning –Supervised learning – Unsupervised learning – Reinforcement learning- Learning tasks.

ANN Paradigms: Multi – layer perceptron using Back propagation Algorithm (BPA), Self – Organizing Map (SOM), Radial Basis Function Network (RBFN), Functional Link Network (FLN).

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

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

Applications of AI Techniques: Load forecasting, Load flow studies, Economic load dispatch, Load frequency control – Single area system and two area system, Reactive power control, Speed control of DC and AC Motors.

Learning Resources:

Text Books:

1. S. Rajasekaran, G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Systems and Evolutionary Algorithms, Synthesis and Applications, Prentice Hall India Pvt., Limited, 2017.

2. S. N. Sivanandam, S.N. Deepa, Principles of Soft Computing, Wiley India Pvt. Limited, 2011, 2nd Edition.

Reference Books:

1. D.E.Goldberg, Genetic Algorithms, Addison-Wesley 2008.
2. A. K. Bhargava, Fuzzy Set Theory Fuzzy Logic and Their Applications, S. Chand, 2013.
3. Thimothy J Ross, Fuzzy Logic with Engineering Applications, Wiley Student Edition, 2016, 3rd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104157/
2. https://nptel.ac.in/courses/108/108/108108148/
3. https://nptel.ac.in/courses/112/105/112105235/

EE1326 **3-0-0 (3)**

Computer Methods in Power Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Design mathematical models for power system components.
CO-2	Select appropriate algorithms for specified power system problems.
CO-3	Generate input data suitable for load flow, fault calculations and state estimation.
CO-4	Apply load flow methods, contingency analysis, and SCADA techniques to modern power system operation and monitoring.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	2	1	1	1	1	1	1	1	3	1
CO-2	3	3	2	2	3	1	1	1	1	1	1	3	1
CO-3	3	3	2	1	2	1	1	2	2	2	1	3	1
CO-4	3	3	3	3	3	1	1	2	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Incidence and network matrices: Introduction, Graphs, Incidence matrices, Primitive matrices, Types of network matrices, formation of network matrix, PI-representation of off-nominal tap transformers, Y-bus by singular transformation, examples of formation of incidence matrices, formation of Y-bus by inspection.

Algorithms for formation of Z-bus matrix: Step by Step algorithm for formation of Z-bus. Modification of Z-bus matrix for changes in the network, example of formation and modification of Z-bus matrix.

Short Circuit calculations: Introduction, Short circuit calculations using $Zbus^{012}$, z_f^{abc}, y_f^{abc}, z_f^{012}, y_f^{012} matrices for various faults, example of short circuit calculations using $Zbus^{102}$ for L-L-L and L-G faults.

Sparsity Technique in Load Flow Studies: Introduction, Sparsity technique for Y-bus and Gauss-Seidel method**.**

Review and Comparison: Gauss-Seidel, Newton - Raphson, Fast decoupled load flow methods. Concept of Contingency analysis. Forward – backward and substitution method for radial distribution systems**.**

Introduction to Real time control of Power System: Introduction, linear State Estimation WLS equations, Types of measurements, D.C power flow based WLS equations, examples of DC based WLS State Estimation, SCADA, communication systems. Role of PMUs in power systems.

Learning Resources:

Text Books:

1. Stagg and ElAbiad, Computer Methods in Power Systems Analysis, McGrawHill ISE, 2019.

2. M.A. Pai, Computer Techniques in Power System Analysis, Tata McGraw-Hill Education, 2017, 3rd Edition.

Reference Books:

1 Hadi Saadat, Power System Analysis, PSA Publishing, 2010.
2 William Stevenson and John Grainger, Power System Analysis, McGraw Hill Education, 2017.
3 Allen J. Wood and Bruce F. Wollenberg, Power Generation, Operation, and Control, Wiley Blackwell, 1996.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=kxm0Prghn64
2. https://www.youtube.com/watch?v=dke92EPNNoA
3. https://www.youtube.com/watch?v=OLmfyXVcszc
4. https://www.youtube.com/watch?v=UL-3R9t_QUk
5. https://www.youtube.com/watch?v=8yPyyWFozbg
6. https://www.youtube.com/watch?v=_uoy5YV8C_8&list=PLbSEVsipX-JRnyo8DjIiPGVP3FbTBo6Ap

EE1328 **3-0-0 (3)**

High Voltage Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the concepts of electric vehicles, hybrid electric vehicles and their impact on environment
CO-2	Analyze the drive-train topologies and advanced propulsion techniques
CO-3	Evaluate hybrid energy storage methodologies
CO-4	Identify the suitable power converter topologies for motor control and hybrid energy storage

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	3	3	2	2	2	1	2	2	3	2
CO-2	3	3	2	3	3	2	1	2	1	3	2	3	2
CO-3	3	3	2	3	3	2	1	2	1	3	2	3	2
CO-4	3	2	2	2	3	1	1	2	1	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Electrostatic fields, their control and estimation: Electric Field intensity, Electric strength, classification of Electric Fields, control of electric Field intensity, basic equations for potential and field intensity in electrostatic fields, Analysis of electric field intensity in homogenous and multi-dielectric electric fields, numerical methods for estimation of electric field intensity.

Generation of high dc and ac voltages: Introduction, Rectifier circuits, Cockcroft-Walton voltage multiplier circuit, electrostatic generator, generation of high ac voltages by cascaded transformers, series resonant circuit.

Generation of impulse voltages and currents: Definitions, impulse generator circuits, Analysis of impulse generator circuit, multistage impulse generator circuit, triggering of impulse generator, impulse current generation.

Measurement of high voltages and currents: Introduction, sphere gap, uniform field spark gap, rod gap, electrostatic voltmeter, generating voltmeter, Fortes cue method, resistive and capacitive voltage dividers, measurement of high DC, AC and impulse currents.

High voltage testing of electrical equipment: Layout of high voltage laboratory with major testing and measuring equipment's, Determination of their ranges and ratings, earthing system, electromagnetic shielding and protective fencing. Testing of overhead line insulators, testing of cables, Testing of Bushings, Testing of power capacitors, testing of power transformers, testing of circuit breakers. IEC, ANSI, IEEE and Indian standards for testing electrical equipment.

Non-destructive testing techniques: Measurement of resistance, measurement of dielectric constant and loss factor, High voltage Schering Bridge, measurement of large capacitances, partial discharges measuring and diagnostic techniques. Time domain and Frequency domain analysis of dielectric materials subjected to an electric field.

Breakdown mechanism of insulating materials: Introduction, Mechanism of breakdown in gases, Townsend's first ionization coefficient, cathode processes, secondary effects, Townsend's second ionization coefficient, Townsend breakdown mechanism, streamer or kanal mechanism of spark, Paschen's law, Penning effect, Breakdown in non-uniform fields, principles of breakdown in solid and liquid dielectrics. Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings.

Learning Resources:

Text Books:

1. Ravindra Arora & Wolfgang Mosch, High Voltage and Electrical Insulation Engineering, Wiley-IEEE Press, 2011.
2. E. Kuffel, W.S.Zaengl, J.Kuffel, High voltage Engineering Fundamentals, Newnes Publishers, 2008.

Reference Books:

1. C. L. Wadhwa: High voltage Engineering, New Age International Publishers, 2020, 4th Edition
2. M. S. Naidu & V. Kamaraju, High-Voltage Engineering, McGraw Hill Education (India) Private limited, 2020, 4th Edition.

Other Suggested Readings:

1. High Voltage Engineering: https://nptel.ac.in/courses/108/104/108104048/

EE1330 **3-0-0 (3)**

Modeling and Analysis of Electrical Machines

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the limitations of conventional models of electrical machines
CO-2	Compute the torque produced in electrical machines using the concept of co- energy
CO-3	Analyze the performance of machines using reference frame theory
CO-4	Evaluate strategies to control the torque for a specific application

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-2	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-4	3	3	3	3	3	3	1	2	1	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Principles for electrical machine analysis and magnetically coupled circuits: Review of basic concepts, magnetizing inductance, Modelling linear and non-linear magnetic circuits.

Electromechanical energy conversion: Principles of energy flow, concept of field energy and co-energy, Derivation of torque expression for various machines using the principles of energy flow and the principle of co-energy, Inductance matrices of induction and synchronous machines.

Theory of DC machines: Review of the DC machine, mathematical model of commutator, State-space model of a DC machine and reduced order model & transfer function of the DC machine.

Reference Frame Theory: Concept of space vector, components of space vector, direct and quadrature axis variables.

Transformation: Types of transformation, condition for power invariance, zero-sequence component, Expression for power with various types of transformation, Transformations between reference frames, Clarke and Park's Transformations, Variables observed from various frames, Simulation studies.

Theory of symmetrical Induction Machines: Voltage and torque in machine variables, Derivation of dq0 model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables, Analysis of steady-state operation, State-space model of induction machine in 'd-*q*' variables, Simulation studies.

Theory of synchronous machines: Derivation of *dq0* model for a salient pole synchronous machine with damper windings using Park's transformation, Torque expression of a salient pole synchronous machine with damper windings and identification of various components.

Learning Resources:

Text Books:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery and Drive systems, Wiley-IEEE Press, August 2013, 3rd Edition.
2. E. Fitzgerald, Charles Kingsley, Stephen D. Umans, Electric Machinery, McGraw Hill Education, July 2017, 6th Edition.
3. Krishnan, Electric Motor Drives: Modeling Analysis: Modeling, Analysis, and Control, Pearson Education India, January 2015, 1st Edition.

Reference Books:

1. Mohammed Fazlur Rahman, Sanjeet K. Dwivedi, Modeling, Simulation and Control of Electrical Drives (Control, Robotics and Sensors), Institution of Engineering and Technology, October 2019, 1st Edition.
2. Shaahin Filizadeh, Electric Machines and Drives: Principles, Control, Modeling, and Simulation, Press, April 2017, 1st Edition.

Other Suggested Readings:

1. http://www.nptelvideos.com/course.php?id=493

EE1332 **3-0-0 (3)**

Electric Vehicle Battery Management Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Explain battery fundamentals, chemistries, and energy storage technologies.
CO-2	Analyze cell form factors, pack integration, and design considerations.
CO-3	Describe the architecture and functionalities of Battery Management Systems.
CO-4	Apply SoC and SoH estimation methods and develop cell balancing strategies.
CO-5	Analyze thermal management systems and electrical protection in EV batteries.
CO-6	Implement BMS algorithms and simulate battery behaviour using MATLAB/Simulink

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	3	3	3	2	3	3	2	3	3	3
CO-2	2	2	2	3	3	3	2	3	3	2	3	3	3
CO-3	2	2	2	3	3	3	2	3	3	2	3	3	3
CO-4	2	2	2	3	3	3	2	3	3	2	3	3	3
CO-5	2	2	2	3	3	3	2	3	3	2	3	3	3
CO-6	2	2	2	3	3	3	2	3	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Batteries: Importance of batteries in EVs, Lithium-ion batteries: why Li-ion and how it works, Battery terminology: SoC, SoH, SOP, C-rate, Cycle ageing vs. calendar ageing, Cell types, chemistries, and comparisons

Battery Pack Design: Battery form factors: cylindrical, pouch, prismatic; Cell construction and welding techniques; Cell-to-cell electrical connections; Electrical, mechanical, and thermal design considerations; Battery sizing basics and use of Excel for design; Cooling mechanisms and thermal management for EV packs

Introduction to BMS: Why BMS is required in EVs; Basic and detailed functions of BMS; BMS architecture: centralized, modular, distributed; BMS control systems and working principles; Development trends in BMS; Cell types, chemistries, and comparisons

Battery Management system Requirements: Battery pack topology; Modelling of battery cells; Empirical modelling; Physical Modelling; BMS design requirement; Battery pack sensing (Voltage, Current, Temperature, Isolation), Thermal control and Protection, Energy estimation, Power estimation, CAN communication.

SOC and SOH Algorithms: State of Charge (SoC) estimation: Coulomb counting, OCV methods; Load Voltage Detect; Initial SoC estimation techniques; Electromotive Force Method; Resistance Method; State

of Health (SoH) estimation: cycle counting, capacity fade; Simulink demonstration for basic SoC/SoH algorithms
Advanced SoC and SoH estimation methods; Kalman Filter approaches for estimation; Equivalent circuit modelling of battery cells; Diffusion voltage modelling; MATLAB/Simulink-based BMS algorithm development
Cell Balancing and Protection: Causes of cell imbalance; Balancer design choices; Passive and active cell balancing techniques; Non-dissipative cell balancing circuits; Electrical protection circuits for overcharge, over discharge, and short circuit; Safe Operating Area (SOA) of lithium-ion batteries, Pre-charge circuit for a battery

Thermal Management and Standards: Thermal modelling of battery packs; Heat transfer, cooling strategies (air, liquid, PCM); Insulation monitoring and safety standards (IEC, ISO); Battery specification sheets and compliance
Industry Applications: EV battery design practices; IC selection for BMS implementation, AIS157 standards and testing, IEC61851 standards.

Learning Resources:

Text Books:

1. Gregory L. Plett, *Battery Management Systems, Vol. 1 & 2*, Artech House, 2015.
2. Rui Xiong, Weixiang Shen, “Advanced Battery Management Technologies for Electric Vehicles”, Wiley, 2019.
3. H.J. Bergveld, W.S. Kruijt, P.H.L. Notten, *Battery Management Systems: Design by Modelling*, Springer, 2002.

Reference Books:

1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, 3rd Edition, CRC Press, 2021.
2. C. C. Chan, K. T. Chau, *Modern Electric Vehicle Technology*, Oxford University Press, 2001.
3. D. Linden, T. B. Reddy, *Handbook of Batteries*, 4th Edition, McGraw-Hill, 2010.
4. SAE / ISO / IEC Standards for EV Batteries and BMS: ISO 26262 – Functional Safety for Road Vehicles; IEC 62619 – Safety Requirements for Secondary Lithium Cells; SAE J2464 – Electric Vehicle Battery Testing
5. Application Notes & Technical Manuals from TI, ADI, and NXP for BMS ICs and design practices.
6. Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House publishers
7. Jiuchun Jiang and Caiping Zhang, Beijing Jiaotong University, China Fundamentals and Applications of Lithium-Ion Batteries In Electric Drive Vehicles, 2015 John Wiley & Sons Singapore Pte. Ltd.

Software / Tools:

1. MATLAB/Simulink
2. PLECS / LTspice
3. Excel for battery sizing
4. CAN communication simulation tools

EE1334 **3-0-0 (3)**

Utilization of Electrical Energy

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the performance and requirements of electric heating and welding methods.
CO-2	Design the lighting schemes for residential, commercial and industrial applications
CO-3	Analyze the schemes of electric traction and traction mechanisms
CO-4	Analyze the control of traction motors, train lighting schemes and coaching wiring

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	-	-	-	2	-	-	-	-	-	-	-	-
CO-2	3	3	-	3	-	2	2	2	2	2	2	2	-
CO-3	3	3	3	3	3	3	3	3	3	-	3	2	-
CO-4	3	2	3	3	2	2	2	2	2	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Electrical Heating and Welding: Electric Heating: Methods and merits of electric heating, resistance heating, induction heating and dielectric heating. **Electric welding**: Welding equipment, resistance welding and arc welding, comparison between AC and DC welding. **Electrolysis**: principle of electrolysis, electroplating, metal extraction and metal processing, electromagnetic stirs. Problems on heating , welding and electrolysis.

Illumination: Terminology & definitions, Laws of illumination, photometry, principle of operation of filament lamps, fluorescent tubes and their comparison. Compact fluorescent lamps (CFL), Light Emitting Diode based lamps, Discharge lamps: mercury vapor lamps, sodium vapor lamps and neon lamps, Principles of light control, Types and design of lighting schemes factory lighting, sports lighting, street lighting and flood lighting. Lighting calculations.

Electric Traction: Systems of electric traction and track electrification- DC system, single phase and 3-phase low frequency and high frequency system, composite system, kando system, comparison between AC and DC systems, Mechanics of traction movement, speed – time curves for different services, trapezoidal and quadrilateral speed–time curves, tractive effort, specific power, specific energy consumption, effect of varying acceleration and braking, retardation, adhesive weight and braking retardation, coefficient of adhesion. Schemes and speed control of traction motors, requirements of train lighting, systems of train lighting, methods of obtaining unidirectional polarity- Rosenberg Generator-single battery system, double battery parallel block system. Lighting by making use of 25KV AC supply. End-on generation, Coach wiring.

Utilization of Electrical Energy in Electric Vehicles: Charging technologies of electric vehicles/hybrid electric vehicles. Charging infrastructure. Utilization of Electrical Energy in Oil and Gas Industry

Learning Resources:

Text Books:

1. E. Openshaw Taylor, Utilisation of Electric Energy, Universities Press, Penram International Publishers, 2010
2. N.V. Suryanarayana, Utilisation of Electrical power including Electric drives and Electric Traction, New Age Publishers, 2017.
3. Tarlok Singh, Utilization of Electric Energy, S.K. Kataria & Sons publishers, Second Edition, 2022

Reference Books:

1. J. B Gupta, Utilization of Electric Power & Electric Traction S.K. Kataria & Sons, Reprint 2020, 10th Edition.
2. H. Partab, Modern Electric Traction, Dhanpat Rai & Co, 2017.
3. E. Openshaw Taylor, Utilisation of Electric Energy, Universities Press, Penram International Publishers, 2010.
4. H. Partab, Art & Science of Utilization of Electric Energy, Dhanpat Rai & Sons, 1998.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105060/

EE1336 **3-0-0 (3)**

Industrial Instrumentation and Automation

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze physical systems using transducers for measurement of physical quantities.
CO-2	Design signal conditioning circuits for measurement and instrumentation systems.
CO-3	Apply industrial automation and control technologies to specified applications.
CO-4	Implement programmable logic controllers (PLCs) for industrial automation problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	2	3	2	1	1	2	2	3	2
CO-2	3	3	3	3	3	2	1	2	2	2	2	3	2
CO-3	3	3	3	3	2	2	1	2	1	3	2	3	2
CO-4	3	3	3	3	3	2	1	3	2	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Static characteristics and static calibration and Dynamic characteristics of Instrument - Zero order, step, ramp and frequency response of first order and second order instrument. Displacement and proximity gauges. Linear Variable Differential Transformer (LVDT) - differential transformer, phase angle adjustment, methods for null reduction, filter frequency response, Hall-effect sensors.

Measurement of Temperature, Flow, Level and Viscosity: Thermocouple, Resistance Temperature Detector (RTD), Thermistor, Radiation Pyrometer, Differential Pressure flow- meter, Variable area flow-meter, Variable reluctance transducer, Turbine flow-meter, Ultrasonic flow-meter (Both transit time and Doppler Shift), electromagnetic flow-meter and Mass flow meter, Capacitance based and Float based method, pH -probe and viscosity measurement and associated Signal Conditioning circuitry.

Measurement of Pressure, strain & Vibration: Estimation of errors and Calibration, Fundamentals of 4-20 mA current loops and 3-15 psi pressure loop, Regulators and power supplies for industrial instrumentation.

Signal Conditioning and Processing: Estimation of errors and Calibration, Fundamentals of 4-20 mA current loops and 3-15psi pressure loop, Regulators and power supplies for industrial instrumentation.

Basics of Data transmission: Synchro and Servo motor. IEEE-488 bus, RS 232 and RS 485 interface. Pneumatic and Hydraulic Instrumentation system

Automation: Benefits and Impact of Automation on Manufacturing and Process Industries; Architecture of Industrial Automation Systems. Data Acquisition systems and PC based automation.

Introduction to Automatic Control: P-I-D Control, Controller Tuning, Special Control Structures, Feed-forward and Ratio Control, Predictive Control, Control of Systems with Inverse Response, Cascade Control. Process and Instrumentation Diagrams;

Sequence Control: Programmable Logic Controllers (PLCs) and Relay Ladder Logic, Scan Cycle, RLL Syntax, Structured Design Approach, Advanced RLL Programming, Hardware environment and distributed control systems (DCS); Control of Machine tools: Introduction to CNC Machines.

Learning Resources:

Text Books:

1. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems, McGraw Hill, 2019, 7th Edition.
2. Albert D. Helfrick and Willium D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, Pearson Education India, 2015, 1st Edition.

Reference Books:

1. A.K. Sawhney, A Course in Electrical Measurements, Electronic Measurements and Instrumentation, Dhanpat Rai and Co., 2015.
2. Alok Barua, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd., 2011.
3. S.K. Singh, Industrial Instrumentation and Control, Tata McGraw-Hill Publishing Company, New Delhi, 2010.
4. M.K. Ghosh, S. Sen and S. Mukhopadhyay, Measurement & Instrumentation: Trends & Applications, Ane Books, 2008.
5. Alan S Morris, Measurement and Instrumentation Principles, Elsevier, 2006.
6. Frank. D, Petruzella, Programmable Logic Controllers, McGraw Hill, 2019, 5th Edition.
7. S. Mukhopadhyay, S. Sen and A. K. Deb, Industrial Instrumentation, Control and Automation, Jaico Publishing House, 2012.

Other Suggested Readings:

1. http://www.nptelvideos.in/2012/11/industrial-instrumentation.html

EE1338 **3-0-0 (3)**

IoT in Electrical Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze IoT concepts and design requirements.
CO-2	Select appropriate Sensors and Actuators for desired application.
CO-3	Compare various technologies and protocols.
CO-4	Design IoT-based solutions for various use cases.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	1	1	1	1	1	1	1	1	1	1	1	1
CO-2	3	2	1	1	1	1	1	1	1	1	1	1	1
CO-3	3	2	1	1	1	1	1	1	1	1	1	2	1
CO-4	3	2	2	2	1	1	1	1	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to IoT: Characteristics of Internet of Things- Need of IoT, IoT architecture, Area of Applications, IoT applications in Smart Cities, Agriculture, Security, Transport and Medical & Health.

IoT Sensing and Actuation: Introduction, Sensors, Sensor Characteristics, Sensorial Deviations, Sensing Types, Scalar sensing, Multimedia sensing, Hybrid sensing, Virtual sensing, Sensing Considerations. Actuators, Actuator Types, Hydraulic actuators, Pneumatic actuators, Electric actuators, Thermal or magnetic actuators, Mechanical actuators, Soft actuators, Actuator Characteristics.

IoT Connectivity Technologies (Fundamentals): Introduction, IEEE 802.15.4, Zigbee, RFID, DASH7, Z-Wave, LoRa, NB-IoT, Wi-Fi, Bluetooth. **Communication Technologies (Fundamentals)**: Introduction, Constrained nodes, Constrained Networks, Infrastructure Protocols, Discovery Protocols, Data Protocols, Identification Protocols, Device Management, Semantic Protocols.

Introduction to Arduino: Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi. **IOT Case Studies**: Agricultural IoT, Components of an agricultural IoT, Advantages of IoT in agriculture, Case Studies, Smart irrigation management system. Vehicular IoT, Components of vehicular IoT, Advantages of vehicular IoT, Crime assistance in a smart IoT transportation system. Healthcare IoT, Components of healthcare IoT, Advantages and risk of healthcare IoT, Case Studies. IoT Case Studies in Electrical Engineering: IoT application to Smart Grid, Smart Cities and Smart Homes, EV Connected Vehicles.

IoT Projects Demonstration: Beginning IoT Hardware Projects, Arduino installation and setup, Setting up Arduino IDE for NodeMCU, Writing an Arduino Sketch, Demo Experiments with Arduino, Printing on the serial console, LED interface with Arduino, DHT Sensor interface with NodeMCU, MQ-2 Gas sensor interface with NodeMCU, Ultrasonic sensor interface with NodeMCU, Obstacle detection using NodeMCU, Servo motor interface with NodeMCU, Relay interface with NodeMCU, Data transmission between

NodeMCU and remote server, Pulse sensor interface with NodeMCU.

IoT Analytics (Basics): Introduction, Machine learning, Advantages of ML, Challenges in ML, Types of ML, Selected Algorithms in ML, k-nearest neighbor (KNN), Decision tree, Random forest, k-means clustering, Agglomerative clustering, Density-based spatial clustering of applications with noise(DBSCAN), clustering, Performance Metrics for Evaluating ML Algorithms.

Paradigms, Challenges, and the Future: Introduction, Evolution of New IoT Paradigms (Discussion Only), Internet of battlefield things (IoBT), Internet of vehicles (IoV), Internet of underwater things (IoUT), Internet of drones (IoD), Internet of space (IoSpace), Internet of services (IoS), Internet of people (IoP), Internet of nano things (IoNT), Internet of everything (IoE). Challenges Associated with IoT, Mobility, Addressing - Power Heterogeneous connectivity, Communication range, Security, Device size.

Application in Electrical Engineering: Induction Machine Control. Home Automation, Smart Meters, SCADA, Asset Maintenance, E-Mobility, Distributed Generation Monitoring.

Learning Resources:

Text Books:

1. Sudip Misra, Anandarup Mukherjee and Arijit Roy, Introduction to IoT, Cambridge University Press, 2021.
2. Dimitrios Serpanos, Marilyn Wolf, Internet-of-Things (IoT) Systems - Architectures, Algorithms, Methodologies, Springer Publications, 2018.

Reference Books:

1. Anandarup Mukherjee, Chandana Roy, Sudip Misra - Introduction to Industrial Internet of Things and Industry 4. 0-CRC Press, 2020.
2. Anuradha, J., Tripathy, B. K, Internet of things (IoT) technologies, applications, challenges and solutions, CRC Press, Taylor & Francis, 2018.
3. Mansaf Alam, Kashish Ara Shakil, Samiya Khan, Internet of Things (IoT) - Concepts and Applications, Springer Publications, 2020.
4. Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems, McGraw Hill, 2019, 7th Edition.
5. Albert D. Helfrick and Willium D. Cooper, Modern Electronic Instrumentation and Measurement, Pearson Education India, 2015, , 1st Edition.

Other Suggested Readings:

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

EE1340 **3-0-0 (3)**

Special Machines

Pre-Requisites: None

Course Outcomes:

CO-1	Select suitable starting methods for single-phase induction motors.
CO-2	Analyze the operating principles and applications of special machines.
CO-3	Identify the suitable applications of special machines.
CO-4	Evaluate the performance of energy efficient and superconducting machines.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	2	2	1	1	1	1	1	2	3	1
CO-2	3	3	2	2	2	1	1	1	1	1	2	3	1
CO-3	3	3	2	3	3	1	1	1	1	1	3	3	3
CO-4	3	2	2	2	3	1	1	1	1	1	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Single Phase Induction Motors: Principle of operation, Double revolving field theory, speed-torque characteristics, Equivalent circuit, Phasor diagrams, Determination of equivalent circuit parameters, Starting methods, Split-phase starting, Resistance starting, Capacitance starting, Shade pole starting, Speed control methods, Applications, Principle of cross field theory, Problem on all the above motors.

Single Phase Synchronous Motors: Construction, principle of operation and applications of Reluctance motors, Hysteresis motors, Sub-synchronous motors

AC Series Motors: Construction, Principle of operation, Phasor diagrams and Characteristics of Single phase and Three Phase AC Series motors, Simple and compensated motors, Universal motors and their applications, Problems on all the above motors

Schrage Motor: Construction, Principle of operation, Speed and power factor control, Applications

Special Purpose Machines: Construction and principle of operation of Stepper motors, Permanent magnet DC motors, Brushless DC motors, Permanent Magnet Synchronous Motors, Switched Reluctance Motors , Linear Induction motors and their Applications, Problems on all the above motors

Energy Efficient Machines: Construction, Basic Concepts, losses minimization and efficiency calculations of Energy efficient AC machines

Super Conducting Machines: Construction, Principle of operation and basic concepts of superconducting AC machines.

Learning Resources:

Text Books:

1. E. Fitzgerald, C. Kingsley and Stepen D. Umans: Electric Machinery, Tata McGraw-Hill Pub., 2020, 7th Edition.
2. P.S. Bimbhra: Generalized Theory of Electrical Machines, Khanna Pub., 2017, 6th Edition.
3. D.P. Kothari and I J Nagarath, Electric Machines, Tata McGraw-Hill Pub., 2017, 5th Edition.

Reference Books:

1. P.S. Kenjo and S.Nagamori, Permanent Magnet DC motors, Clarendon Press, Oxford,1985.
2. J.B. Gupta, Theory and Performance of Electrical Machines, S. K. Kataria & Sons, 14th Edition, 2006.
3. H. Cotton, Advanced Electrical Technology, Reem Publications, 2011.
4. Stephen J. Chapman, Electric Machinery Fundamentals, Tata McGraw - Hill Education, 4th Edition, 2017.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102156/

EE1342 **3-0-0 (3)**

Python Programming

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze problem-solving techniques using algorithms and procedures
CO-2	Implement simple Python programs for specified applications.
CO-3	Apply Python data structures – lists, tuples and dictionaries
CO-4	Develop Algorithms and Code in Python Language.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	2	1	2	3	1	1	2	2	3	2	2
CO-2	3	2	2	1	2	3	1	1	2	2	3	2	2
CO-3	3	2	2	1	2	3	1	1	2	2	3	2	2
CO-4	3	3	3	2	3	3	3	2	2	2	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Syntax: Data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments; understanding error messages; Conditions, Boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation.

Strings and text files; manipulating files and directories, OS and SYS modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers.

Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Functions: create, call, arguments and return values, arbitrary arguments, keyword arguments, arbitrary keyword arguments, default argument Recursive functions

Introduction to classes and OOPS.

Modules, Introduction to NumPy, SciPy, MatPlotLib, Pandas, Tensorflow.

File Handling – create and delete files, read and write into text and excel files.

Exception Handling, try-except, raising and exception, else and finally blocks, handling multiple exceptions.

List of Experiments:

1. Programs using sequential constructs
2. Programs using selection constructs

3. Programs using Iterative constructs
4. Programs using nested for loops
5. Programs using lists, tuples and dictionaries
6. Simple Python functions
7. File Handling
8. Modules
9. Functions and Recursion
10. Exception Handling

Learning Resources:

Text Books:

1. Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
2. Allen B. Downey, Think Python: How to Think like a Computer Scientist, Updated for Python 3, O'Reilly Media, Publishers, 2015, 2nd Edition.

Reference Books:

1. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
2. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, 2017.
3. John V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
4. Mark Lutz, "Learn Python"", 5th Edition, O'reilly Media, Inc, June, 2013.

Other Suggested Readings:

1. https:/ /nptel.ac.in/courses/106106182/
2. https:/ /www.python.org
3. http://greenteapress.com/wp/thinkpython/

EE1344 **3-0-0 (3)**

Energy System Analytics

Pre-Requisites: None

Course Outcomes:

CO-1	Explain the role of analytics in energy sector.
CO-2	Prepare, clean, and visualize energy datasets for analytical modeling.
CO-3	Perform descriptive, diagnostic, and anomaly detection analyses on energy data.
CO-4	Develop and evaluate time-series forecasting models for generation, load, or storage data.
CO-5	Utilize analytics for energy market forecasting, trading, and risk-informed decision-making.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	1	1	1	3	1	1	2	2	3	2	2
CO-2	3	3	2	1	1	3	1	1	2	2	3	2	2
CO-3	3	3	3	1	1	3	1	1	2	2	3	2	2
CO-4	3	3	3	2	2	3	3	2	2	2	3	3	2
CO-5	3	3	3	3	2	3	3	2	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Role of analytics in energy sector, Types of energy data (generation, demand, storage, grid, IoT), Descriptive / diagnostic / predictive / prescriptive analytics, Introduction to tools: Python/R, dashboards.

Data Collection, Preparation & Organization: Sources of energy data (SCADA, sensors, market, grid), Data quality, missing values, outliers, Data pre-processing and feature engineering, Time-series vs cross-sectional data, Exploratory data analysis & visualization

Analytics Foundation: Summary statistics: mean, median, variance, correlation, Trend/seasonality in energy data, Anomaly detection: e.g., underperformance of a solar array

Time-Series & Forecasting Methods: Time-series modelling: decomposition, ARIMA, exponential smoothing, Forecasting generation (solar, wind), storage usage, load/demand, Incorporating exogenous variables (weather, market, storage state), Evaluation of forecasting models

Machine Learning & Advanced Analytics in Energy Sector: Regression, classification, clustering in energy context, ML for fault-prediction, Deep learning methods, Prescriptive analytics: optimisation (e.g., storage dispatch, scheduling), Analytics for battery energy storage systems (BESS) & pumped hydro, Grid integration: demand-response, congestion forecasting, renewable variability, IoT data integration and edge/real-time analytics

Market & Trading Analytics: Energy markets fundamentals, Price forecasting, trading strategy analytics, Risk & uncertainty in energy markets, using analytics to inform investment or operational decisions

Learning Resources:

Text Books:

1. Sioshansi, F. P. Energy, Information, and Power Systems Analytics. Academic Press, 2020.
2. Kleissl, J. Solar Energy Forecasting and Resource Assessment. Academic Press, 2013.
3. Kuhn, M., Johnson, K. Applied Predictive Modelling. Springer, 2013.

Reference Books:

1. Goodfellow, I., Bengio, Y. Deep Learning. MIT Press, 2016.
2. Hands-On Machine Learning for Energy Systems – Online resources and open datasets (NREL, EIA, Kaggle).

Software / Tools:

1. Simulation: MATLAB/Simulink, HOMER Pro, EnergyPLAN, PyPSA, or OpenModelica.
2. Optimisation: Python (Pyomo, Gurobi, Scipy Optimize).
3. Data Analytics: Excel, Python (Pandas, Matplotlib).
4. IoT Platform: Blynk / Node-RED / ThingSpeak for real-time system monitoring

EC1364 **3-0-0 (3)**

Synthesis of Digital Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Design combinational and sequential logic circuits
CO-2	Develop Verilog HDL models for combinational and sequential logic circuits
CO-3	Synthesize combinational and sequential logic circuits using Verilog HDL
CO-4	Analyze PLD/CPLD/FPGA organization and digital circuit mapping.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-2	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-4	3	3	3	3	3	3	1	2	1	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Overview of Digital Design with Verilog HDL: Emergence of HDLs, Typical Design flow, Hierarchical modelling concepts, Lexical conventions, data types, Gate level Modeling, Dataflow Modeling, Behavioral Modeling, Structural Modeling, Logic Synthesis with Verilog HDL.

Combinational circuits design: Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carry-look ahead adder; Parallel prefix adders- Carry select Adder, Verilog models of combinational circuits.

Sequential circuit design: Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop Synthesis of synchronous sequential circuits, Mealy and Moore machines, state minimization. Registers, synchronous and asynchronous counters Verilog models of sequential circuits.

Memory and Programmable logic devices: RAM, ROM- Cell Organization, Memory decoding, PAL, PLA, CPLD and FPGA

Testing of Fault Analysis: Types of Faults, Hazards in the Logic Circuits Testing of Combinational Logic Circuits, Testing of Sequential Logic Circuits.

Learning Resources:

Text Books:

1. Digital Design with an introduction to the Verilog HDL, Morris. M. Mano, Michael D.Ciletti, Prentice-Hall India, 2013, 5th Edition.
2. Charles H. Roth, Jr, Thomson Brooks /Cole Fundamentals of Logic Design, 2005, 5th Edition.
3. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2004, 2nd Edition.

Reference Books:

1. S. Brown and Z. Vranesic, Fundamentals of digital logic with Verilog design, McGraw-Hill, 2013, 3rd Edition.
2. Charles, H. Roth, Jr, Thomson Brooks /Cole, Digital System Design using VHDL, Indian Edition, 2006.
3. Mohammad A.Karim, Xinghao Chen, Digital Design, CRC press, 2008.
4. J.F. Wakerly, Digital Design Principles and Practices, Prentice Hall, 2008, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106177/

EE1421 **3-0-0 (3)**

Switched Mode Power Conversion

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the operation of DC-DC converters with current and voltage mode control
CO-2	Analyze resonant converters and their control techniques
CO-3	Design DC-DC converters and their feedback control loops
CO-4	Analyze the operation and control of multilevel inverters

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	2	3	1	1	2	1	2	3	3	3
CO-2	3	3	3	2	3	1	1	2	1	2	2	3	3
CO-3	3	3	3	3	3	1	1	3	1	3	3	3	3
CO-4	3	3	3	2	3	1	1	2	1	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

DC/DC Converters and Current Mode control: Basic topologies of buck, boost converters, buck-boost converters and cuk converter, isolated DC/DC converter topologies: forward, and fly-back converters, half and full bridge topologies, modeling of switching converters. Voltage mode and current mode control of converters, peak and average current mode control, its advantages and limitations, voltage and current fed converters.

Resonant Converters: Need for resonant converters, types of resonant converters, methods of control, phase- modulation technique with ZV Sin full-bridge topology, series resonant converter and resonant transition converter.

Converter Transfer Functions: Application of state-space averaging to switching converters, derivation of converter transfer functions for buck, boost and fly-back topologies.

Power Converter Design: Design of filter inductor & capacitor, and power transformer, Ratings for switching devices, current transformer for current sensing, design of drive circuits for switching devices, considerations for PCB layout.

Controller Design: Introduction, mechanisms of loop stabilization, shaping E/A gain vs. frequency characteristic, conditional stability in feedback loops, stabilizing a continuous mode forward converter and discontinuous mode fly-back converter, feed-back loop stabilization with current mode control, the right-half plane zero.

Inverters: SVM technique, multilevel inverters and PWM methods.

Learning Resources:

Text Books:

1. Ned Mohan Tore M. Undeland: Power Electronics: Converters, Applications, and Design, John Wiley & Sons, 2007, 3rd Edition.
2. Abraham I. Pressman, "Switching Power Supply Design", McGraw Hill International, 2009, 3rd Edition.

Reference Books:

1. P. C. Sen: Modern Power Electronics, S.Chand - 2005.
2. Krishna K Gupta and and Pallavee Bhatnagar, Multilevel Inverters: Conventional and Emerging Topologies an their Control, Elsevier Science, 5 December 2017.
3. Keng C. Wu, Switch-Mode Power Converters: Design and Analysis by,Elsevier Science, December 2005.
4. Andrzej M. Trzynadlowski Introduction to Modern Power Electronics, illustrated Publisher John Wiley & Sons, 2010, 2nd Edition.
5. Muhammad H. Rashid, Power electronics handbook, Butterworth-Heinemann, 2018, 4th Edition.
6. BinWu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=P0MK7sWfs9k
2. https://www.youtube.com/watch?v=SRVswRH5Q7E
3. https://nptel.ac.in/courses/108/102/108102157/
4. https://nptel.ac.in/courses/108/108/108108035/

EE1423 **3-0-0 (3)**

Planning an Entrepreneurial Venture

Pre-Requisites: None

Course Outcomes:

CO-1	Apply entrepreneurial practices to new venture creation
CO-2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO-3	Explore the opportunities in the domain of Electrical, Electronics and Computer Engineering for launching a new venture
CO-4	Analyze the functional management issues of running a new venture

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	2	1	2	1	1	2	2	2	2	2
CO-2	2	2	2	2	1	3	2	1	2	2	2	2	2
CO-3	2	2	2	2	1	1	1	2	3	2	3	2	3
CO-4	2	2	2	2	1	3	1	1	2	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Entrepreneur and Entrepreneurship: Entrepreneurship and Small-Scale Enterprises (SSE); Role in Economic Development, Entrepreneurial Competencies; Institution Interface for SSE.

Establishing the Small-Scale Enterprise: Opportunity Scanning in the domain of Electrical, Electronics and Computer Engineering; Opportunity Identification in the domain of Electrical, Electronics and Computer Engineering; Market Assessment for SSE; Choice of Technology and Selection of Site; Financing the New/Small Enterprises; Preparation of the Business Plan; Ownership Structures and Organizational Framework

Operating the Small-Scale Enterprises: Financial Management Issues in SSE; Operational Management Issues in SSE; Marketing Management Issues in SSE; Organizational Relations in SSE.

Case Studies: Selected Success Stories of Contemporary Entrepreneurs for imbibing positive psychology among the students for launching new ventures.

Learning Resources:

Text Books:

1. Kuratko, New Venture Management: The Entrepreneur's Roadmap, Pearson, 2008.
2. Holt, Entrepreneurship: New Venture Creation, PHI(P) Ltd., 2001.

Reference Books:

1. Madhulika Kaushik, Management of New & Small Enterprises, IGNOU course material, 1995.
2. B S Rathore, S Saini, Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
3. P C Jain, A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
4. J B Patel, D G Allampalli, EDII A Manual on How to Prepare a Project Report, Ahmedabad, 1991.
5. J B Patel, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

Other Suggested Readings:

1. Champions Portal: www.champions.gov.in
2. Udyam Registration: https://udyamregistration.gov.in
3. MSME Databank: www.msmedatabank.in
4. National Small Industries Corporation: www.nsic.co.in
5. MSME Sambandh: sambandh.msme.gov.in
6. Government eMarket Place: www.gem.gov.in

EE1425 **3-0-0 (3)**

Illumination Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the characteristics of illumination sources / devices.
CO-2	Analyze the performance of various lighting systems.
CO-3	Design lighting control and management systems.
CO-4	Apply lighting standards and commissioning requirements to specified systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	1	1	1	1	3	1
CO-2	3	3	3	2	2	1	1	1	2	1	1	3	1
CO-3	3	3	3	3	3	2	2	1	1	1	1	3	3
CO-4	3	3	3	2	1	2	3	2	1	1	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Ballast based Systems: Introduction - Magnetic and Electronic Ballast – Dimming Electronic Ballast for Fluorescent lamps - Lamp Ballast interactions – Electronic Ballast for HID Lamps - Pulse start metal halide system, Compact Fluorescent lamp.

Solid State Lamps: Introduction – Review of Light sources – white light generation techniques- Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs- Electrical and optical properties – LED driver considerations- Power management topologies- Thermal management considerations- Heat sink design- photometry and colorimetry - color issues of white LEDs- Dimming of LED sources -Designing usable lamp from white LEDs,- Luminaire design steps-SSL test standards. Dimming control scheme- Lighting controls for LED lamps.

Lighting Controls & management: Introduction to lighting control – lighting control strategies – Energy Management strategies– Switching Control–sensor technology- occupancy sensors– PIR– Ultrasonic location, coverage area & mounting configuration – special features – Application. Photo sensors –spectral sensitivity – Photo sensor-based control algorithms – Daylight-artificial light integrated schemes.

Commissioning of lighting controls: NASHRAE / IESNA standards & energy codes – international energy conservation code–compliance with controls Lighting Control Applications: Commercial lighting stage and entertainment lighting–Architectural lighting–Residential Lighting Energy Management and building control systems.

Learning Resources:

Text Books:

1. Arturas Zukauskus, Michael S. Shur and Remis Gaska, Introduction to solid state lighting, Wiley-Interscience, 2002.

2. E. Fred Schubert, Light Emitting Diodes, Cambridge University Press, 2006, 2nd Edition.

Reference Books:

1. Craig Di Louie, Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications, Fairmont Press, Inc.,2006.
2. S. M. Chaudhari, Illumination Engineering, Nirali Prakashan, 2019, 1st Edition.
3. Jack L. Lindsey, Applied Illumination engineering, Fairmont Press, 2015, 2nd Edition.
4. Mohan, Undeland and Robbins, Power Electronics: Converters, Applications and Design, John Wiley and Sons, 1989.
5. Steve Winder, Power Supplies for LED Driving, Newnens Publication, 2008.
6. Robert S Simpson, Lighting Control: Technology and Applications, Focal Press, 2003. IES Lighting Handbook, 2011, 10th Edition IESNA.

Other Suggested Readings:

1. www.aboutlightingcontrols.org

EE1427 **3-0-0 (3)**

Power Quality

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Estimate the severity of power quality issues and implement solutions, considering both end-user and system-level perspectives.
CO-2	Identify power quality issues, including transients, voltage variations, imbalance, waveform distortion, and fluctuations.
CO-3	Analyze sources of voltage sags, interruptions, and transient overvoltage's.
CO-4	Design and implement solutions to mitigate power quality issues, such as voltage regulation techniques, protection against transient overvoltage's, harmonic filtering, and strategies for managing long-duration voltage variations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	1	1	1	1	1	1	1	3	2
CO-2	3	3	3	3	1	1	1	1	1	1	1	3	2
CO-3	3	3	3	3	1	1	1	1	1	2	1	3	2
CO-4	3	3	3	3	3	1	1	1	1	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Power Quality – Voltage Quality; Concerns about Power Quality; The Power quality Evaluation Procedure

Terms and definitions: General Classes of Power quality Problems: Transients, Long-Duration Voltage variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage fluctuation, Power Quality Terms, CBEMA and ITI Curves

Voltage sags and interruptions: Sources of Saga and Interruptions, Estimating voltage Sag Performance, Fundamental Principles of Protection, Solution at the End-User Level, Motor –Starting Sags

Transient over voltages: Sources of Transient Over voltages, Principles of Over voltage Protection, Devices for Over voltage Protection, Utility Capacitor-Switching transients, Utility System Lightning Protection, Managing Ferro-resonance, Switching Transient Problems with Loads, Computer Tools for Transients Analysis

Fundamentals of harmonics: Harmonic Distortion, Voltage versus Current Distortion ,Harmonics versus Transients, Harmonic Indexes, Harmonic Sources from Commercial Loads ,Harmonic Sources from Industrial Loads , Locating Harmonic Sources, Effects of Harmonic distortion, Interharmonics, Harmonic distortion Evaluations, Principles for Controlling Harmonics, Harmonic Filter design: A Case Study, Standards of Harmonics

Long-duration voltage variations: Principles of Regulating the Voltage, Devices for Voltage Regulation, Utility Voltage Regulator application, Capacitors for Voltage Regulation, End-Users Capacitors Application, Regulating Utility Voltage with distributed Resources Flicker

Power quality monitoring: Monitoring considerations, Historical Perspective of Power quality Measuring Instruments, Power Quality Measurement Equipment, Assessment of Power Quality Measurement Data, Application of intelligent Systems, Power Quality Monitoring Standards, Monitoring considerations.

Learning Resources:

Text Books:

1. Dugan Roger C, Santoso Surya, Mc Granaghan , Marks F. Beaty and H. Wayre, Mc Graw Hill , Electrical Power Systems Quality, McGraw Hill, 2012, 3rd Edition.
2. Math H. Bollen, Understanding power quality problems, Wiley - IEEE press, 2019
3. Ghosh Arindam, Ledwich Gerard, Power Quality Enhancement Using Custom Power Devices, Springer, 2002.

Reference Books:

1. Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Arede, Instantaneous Power Theory and Applications to Power Conditioning, Wiley-IEEE Press, 2017.
2. J. Arrillaga, N.R. Watson, Power System Harmonics, Wiley, 2003, 2nd Edition.
3. Mahesh Kumar Mishra, Power Quality in Power Distribution Systems Concepts and Applications, CRC Press, 2023
4. Ghosh Arindam, Ledwich Gerard, Power Quality Enhancement Using Custom Power Devices, Springer, 2009.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/108/102/108102179/
2. https://archive.nptel.ac.in/courses/108/107/108107157/
3. https://archive.nptel.ac.in/courses/108/106/108106025/

EE1429 **3-0-0 (3)**

Quantum Computing Techniques in Electrical Engineering

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Analyze the fundamental postulates of quantum mechanics and their implications for computation.
CO-2	Explain the working of qubits, gates, and quantum circuits
CO-3	Interpret core quantum algorithms and their applications.
CO-4	Identify potential applications of quantum computing in EE domains

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	1	1	1	1	3	1	1	2	3
CO-2	3	3	3	3	1	1	1	2	2	1	1	3	2
CO-3	3	3	3	3	1	1	1	1	3	2	1	3	2
CO-4	3	3	3	3	1	1	1	1	3	3	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Foundations of Quantum Computing: Classical vs. Quantum computation**,** Key postulates of quantum mechanics (superposition, measurement, entanglement), Qubits and state vectors, Dirac notation and Bloch sphere visualization

Quantum Gates and Circuits: Single-qubit gates (Pauli, Hadamard, Phase, T), Multi-qubit gates (CNOT, Toffoli, Swap), Quantum circuit representation, Reversibility and unitary operations

Quantum Algorithms – Fundamentals: Deutsch and Deutsch–Jozsa algorithms, Grover's search algorithm and speedup, Shor's algorithm for integer factorization, Quantum Fourier Transform (QFT) basics

Quantum Algorithms in Engineering Computation: Optimization problems in engineering and their classical limitations, Introduction to Quantum Approximate Optimization Algorithm (QAOA), Variational Quantum Eigen solver (VQE) and energy minimization, Case Study: Economic load dispatch and unit commitment through quantum optimization

Quantum Signal Processing and Control: Quantum Fourier Transform and spectral analysis, Quantum state tomography and measurement-based filtering, Quantum principal component analysis (qPCA) concepts

Quantum Computing in Electrical Engineering Systems: Role of quantum computing in: i) Power system optimization and scheduling ii) Smart grid cybersecurity (QKD concepts) iii) Optimal energy management of large-scale systems iv) Unit Commitment and Economic Load Dispatch

Future directions: Hybrid quantum–classical systems, Comparison of platforms: IBM Q, D-Wave, Google Sycamore, Near-term quantum computers (NISQ era), Introduction to Qiskit and Cirq.

Learning Resources:

Text Books:

1. Nielsen, Michael A., and Isaac L. Chuang. Quantum Computation and Quantum Information. Cambridge, UK: Cambridge University Press, September 2000. ISBN: 9780521635035
2. Easttom W. Quantum computing fundamentals. Hoboken (NJ): Pearson Education; 2021.
3. LaPierre R. Introduction to quantum computing. The Materials Research Society Series. Cham: Springer; 2021.
4. Combarro EF, González-Castillo S. A Practical Guide to Quantum Computing: Hands-On Approach to Quantum Computing with Qiskit. Packt Publishing Ltd; 2025 Jul 30.

Reference Books:

1. Satheesan S, Kalidasu M. Quantum computing concepts: fundamentals, circuits, and code (English edition). New Delhi: BPB Publications; 2025.
2. Wong, H.Y.: Introduction to Quantum Computing: From a Layperson to a Programmer in 30 Steps. Engineering. Springer, (2022)
3. Khang A, editor. Applications and principles of quantum computing. IGI Global; 2024 Jan 31.
4. Peres, Asher. Quantum Theory: Concepts and Methods. New York, NY: Springer, 1993. ISBN: 9780792325499.

Reading:

1. Silva, F.F.C., Carvalho, P.M.S. & Ferreira, L.A.F.M. A quantum computing approach for minimum loss problems in electrical distribution networks. Sci Rep 13, 10777 (2023). https://doi.org/10.1038/s41598-023-37293-9

2. Ajagekar A, You F. Quantum computing based hybrid deep learning for fault diagnosis in electrical power systems. Applied Energy. 2021 Dec 1;303:117628.

Online Resources**:**

1. IBM Quantum's Quantum for Energy Webinar Series
2. IEEE Quantum Week Tutorials on Quantum Energy Applications
3. https://nptel.ac.in/courses/106106232
4. https://nptel.ac.in/courses/104104082

EE16025 **3-0-0 (3)**

Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the concepts of electric vehicles, hybrid electric vehicles and their impact on environment
CO-2	Analyze the drive-train topologies and advanced propulsion techniques
CO-3	Evaluate hybrid energy storage methodologies
CO-4	Identify the suitable power converter topologies for motor control and hybrid energy storage

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	1	1	1	1	1	1	1	3	2
CO-2	3	3	3	3	1	1	1	1	1	1	1	3	2
CO-3	3	3	3	3	1	1	1	1	1	2	1	3	2
CO-4	3	3	3	3	3	1	1	1	1	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Conventional vehicle, basics of vehicle performance, History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive- trains on energy supplies.

Hybrid Electric Vehicles: Micro hybrid vehicles, mild hybrid vehicles, full hybrid vehicles, configuration of hybrid electric Vehicles -Parallel hybrid, series Hybrid, Series-Parallel Hybrid, Complex Configuration. Power flow diagrams Hybrid electric vehicle configurations for various operating modes. Plug-in Hybrid Vehicles: Operating principle, architectures: series-parallel-series-parallel, challenges related to grid connection. Range-extended Electric Vehicles: Classification and configurations, Fuel Cell Electric Vehicles, Solar electric Vehicles, Electric Bi-cycles and their propulsion systems, Vehicle-to-grid, vehicle-to-home concepts, Electric Hybrid electric vehicles-configurations, Solar powered vehicles.

Electric drive-trains: Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis

Electric propulsion unit: Electric components used in electric vehicles, Configuration and control schemes of DC Motor drives, Induction Motor drives, BLDC motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives.

Energy Storage: Storage requirements for Electric Vehicles, Battery energy storage, Fuel Cell based energy storage, Super Capacitor based energy storage and Super Magnetic Energy storage (SMES). Power pack management systems, Active and passive Cell balancing techniques. Hybridization of different energy storage devices, Flywheel based energy storage, compressed air storage systems, super magnetic storage systems.

Converters for Hybrid Energy Storage Systems: Converter configurations for hybrid energy systems based on Battery and Ultra Capacitors-cascaded converter, multiple parallel- connected converter, dual-active-bridge converter, multiple-input converter- multiple modes single converter, interleaved converter, switched capacitor converter, coupled inductor based configurations.

Fundamentals of Chargers: Charger classifications and standards, selection of AC charging systems, DC charging systems, Converter topologies for charging, wireless chargers.

Learning Resources:

Text Books:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2021, 3rd Edition.

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2023, 3rd Edition.
2. James D. Halderman, Curt Ward, Pear Son, Electric and Hybrid Electric Vehicles, 2023, 1st Edition.
3. Aunpam Singh, Electric Vehicles and the end of ICE Age, 2022, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/

EE36021 **3-0-0 (3)**

Restructured Power Systems

Pre-Requisites: None

Course Outcomes (COs):

CO1	Analyze the need for restructured power system and economics.
CO2	Evaluate transmission congestion and loss allocation in power systems.
CO3	Optimize the economic operation of power systems in a restructured environment.
CO4	Analyze the need for ancillary services and demand response in restructured power systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Restructuring of power industry and Fundamentals of Economics- Introduction, Reasons for restructuring / deregulation of power industry, Fundamentals of Deregulation, Motivation of restructuring the power industries, restructuring process – unbundling & privatization, restructuring models, Components of restructured systems, fundamentals of Economics.

Power Market Reforms- Reforms in Indian power sector, Independent System Operator (ISO): Functions and responsibilities, Smart Grid trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems, and Open Access Same Time Information system (OASIS)

Transmission Pricing & Congestion Management- Cost components, Postage Stamp Method, Megawatt Mile Method, Contract Path Method. Classification of congestion management methods, Calculation of ATC-TTC-CBM, Non-market methods, Market based methods, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management, Locational Marginal Prices.

Economic Operation in restructured Environment - Economic dispatch problem and methods of solutions, Optimal Power flow (OPF), General OPF formulation, Security constrained OPF, Solution techniques, OPF application in Electricity Market.

Risk Management in Restructured Environment- Energy and Reserve Markets, Market Power, Forward and Future market, Smart grid Optimization with risk constraints-General risk measures, Portfolio selection problem, Financial Transmission Rights.

Ancillary Services Management and Demand Response in Restructured Environment -Reactive power as an ancillary service, Energy Storage System, Power Quality, Reliability analysis, Demand response, Potential benefits of demand response in smart grid, enabling smart technologies for demand response, Demand response for Electric Vehicles.

Impact of Energy Transition on Power System restructuring – Key drivers in energy transition, role of power market in energy transition, re-organizing power systems for the transition.

Learning Resources:

Text Books:

1. L. L. Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd., 2012, 1st Edition.
2. K. Bhattacharya, J. E. Daadler, and Math H.J Bollen, Operation of restructured power systems, Kluwer Academic Pub., 2012, 1st Edition (Reprint).
3. D. Kirschen and G. Strbac, Fundamentals of Power System economics, John Wiley & Sons Ltd,2019, 2nd Edition.

Reference Books:

1. S. Hunt,, Making competition work in electricity, John Wiley & Sons, Inc., 2002, 1st Edition.
2. Ashikur Bhuiya, Power System Deregulation: Loss Sharing in Bilateral Contracts and Generator Profit Maximization, VDM Verlag Publisher, 2008

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/108/104/108104052/
2. https://archive.nptel.ac.in/courses/108/101/108101005/

EE46001 **3-0-0 (3)**

Linear Control System

Pre-Requisites: None

Course Outcomes:

CO-1	Model the dynamical systems using the state-space concept
CO-2	Solve the state space equation and perform the stability analysis
CO-3	Design the control systems using state-space methods
CO-4	Implement the observer based controller concept and optimal control problem

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Mathematical modelling of LTI control systems - impulse response model, differential equation model, transfer function model, frequency response model, state space model-Introduction to state and state variables – State space - physical systems - Representation using state space approach- Modelling of electrical systems

Control system Analysis in state space: State space representations of transfer functions, Solution of state space equation - State transition matrix -Matrix exponential-Controllability and observability

Control system Design in State space: Pole placement approach to Regulator design-Full order observer- Observer based regulator design

Stability concept: Stability in the sense of Lyapunov - stability of linear systems – Lyapunov equation-Generation of Lyapunov functions-Krasovskii's method Quadratic optimal control-Lyapunov's approach to quadratic optimal regulator design.

Learning Resources:

Text Books:

1. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 2020, 5th Edition.
2. M. Gopal, Modern Control Systems Theory, New Age International Publisher, 2023, 5th Edition

Reference Books:

1. Panos J. Antsaklis, Anthony N. Michel, A Linear Systems Primer, Birkhauser Boston Inc, 2007, 1st Edition.
2. Roy Choudhary, Modern Control Engineering, Prentice Hall India, 2005, 1st Edition.
3. Brogan W. L, Modern Control Theory, Prentice Hall, 2011, 3rd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108106150
2. https://nptel.ac.in/courses/101108057

EE1422 **3-0-0 (3)**

HVDC and FACTS

Pre-Requisites: None

Course Outcomes:

CO-1	Compare HVDC and HVAC transmission systems.
CO-2	Evaluate the performance of converter configurations for HVDC and FACTS systems.
CO-3	Analyze the operation of power flow controllers and harmonic generation in DC links.
CO-4	Analyze and select a suitable FACTS controller for a given power flow condition.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	1	1	1	1	1	1	1	1	1	3	1
CO-2	3	3	2	2	3	1	1	1	1	1	1	3	1
CO-3	3	3	3	3	3	2	1	1	1	2	1	3	1
CO-4	3	3	3	3	3	1	1	3	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

HVDC Transmission: DC Power Transmission: Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC Transmission systems, Types of DC links, relative merits, Components of a HVDC system, Modern trends in DC Transmission systems

Analysis of HVDC Converters: Pulse number, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms

HVDC Control: Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current Control, CEA Control, firing angle control of valves, starting and stopping of a dc link, Power control

Harmonics and Filters: Effects of Harmonics, sources of harmonic generation, Types of filters–Design examples

Power Flow Analysis in AC/DC Systems: Modelling of DC links, solutions of AC-DC Power flow

Flexible AC Transmission Systems (FACTS): FACTS concepts and general system conditions: Power flow in AC systems, Relative importance of controllable parameters, Basic types of FACTS controllers, shunt and series controllers, Current source and Voltage source converters (qualitative treatment only).

Static Shunt Compensators: Objectives of shunt compensation, Methods of controllable VAR generation, Static Var Compensator, its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle, control approaches and characteristics

Static Series Compensators: Objectives of series compensator, variable impedance type of series compensators, TCSC, TSSC-operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating, Capability to provide reactive power compensation, external control

Combined Compensators: Introduction to Unified Power Flow Controller, Basic operating principles, Conventional control capabilities, Independent control of real and reactive power.

Special FACTS devices: TCBR, NGH - SSR damper, SMES, TCPAR and D-FACTS (DSTATCOM & UPQC).

Learning Resources:

Text Books:

1. K.R.Padiyar, HVDC Power Transmission Systems –Technology and System Interactions, New Age International Publishers, 2017, 3rd Edition.
2. Kimbark, Direct Current Transmission, Wiley–Blackwell Publishers, Vol.1, 1971.

Reference Books:

1. Narain G. Hingorani, Laszlo Gyugyi Understanding FACTS –Concepts and Technology of Flexible AC Transmission Systems, Wiley India Pvt Ltd, 2011.
2. Jos Arrillaga, High Voltage Direct Current Transmission, Institution of Engineering and Technology, 1998, 2nd Edition.
3. Yong Hua Song, Allan T Johns, Flexible AC Transmission Systems, Institution of Engineering and Technology, 1999.

Other Suggested Readings:

1. HVDC Transmission: https://nptel.ac.in/courses/108/104/108104013/
2. FACTS: https://nptel.ac.in/courses/108/107/108107114/

EE1424 **3-0-0 (3)**

Smart Grid Technologies

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the features of Smart Grid in the context of Indian Grid.
CO-2	Analyze the role of automation in Transmission/Distribution
CO-3	Apply Evolutionary Algorithms for the Smart Grid/Distribution Generation.
CO-4	Evaluate the operation and importance of PMUs, PDCs, WAMS, and voltage and frequency control in microgrids.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	1	1	1	1	1	1	1	1	1	3	1
CO-2	3	3	2	2	3	1	1	1	1	1	1	3	1
CO-3	3	3	3	3	3	2	1	1	1	2	1	3	1
CO-4	3	3	3	3	3	1	1	3	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Smart Grid: Introduction to Smart Grid - Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – dimensions of smart grid-Key Challenges for Smart Grid**.**

Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable and distributed energy Integration.

Tools and Techniques for Smart Grid: Computational Techniques – Static and Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms-Artificial Intelligence techniques.

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

Communication Technologies: Introduction to Communication Technology-Synchro-Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS).

Control of Smart Grid System and Smart Cities: Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids, Smart Grids to the Smart Cities: New Paradigms for Future Networks.

Learning Resources:

Text Books:

1. Mani Vadari, Smart Grid Redefined: Transformation of the electric utility. Artech House, 2018.
2. Stuart Borlase, Smart Grids, Infrastructure, Technology and Solutions, CRC Press, 2013.

Reference Books:

1. M. L. Scala, S. Bruno, C. A. Nucci, S. Lamonaca, U. Stecch, Smart Grids to the Smart Cities: New Paradigms for Future Networks, Vol-II, Wiley publication, 2017.
2. N. Ramesh Babu, Smart Grid Systems: Modeling and Control, 1st ed, CRC Press, 2019.
3. A.G. Phadke and J.S. Thorp Synchronized Phasor Measurements and their Applications, Springer Edition, 2010.
4. Mini.S. Thomas, John D McDonald, Power System SCADA and Smart Grids, CRC press, Taylor & Francis group, 2015.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/107/108107113/
2. https://www.coursera.org/lecture/electric-power-systems/smart-grid-utilities-consumers- TSfBn

EE1426 **3-0-0 (3)**

Advanced Electrical Drive Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Design controllers for closed-loop operation of separately excited DC motor drives
CO-2	Develop high performance induction motor drives using the principles of Scalar control, Vector control and Direct Torque Control
CO-3	Develop the control strategies for doubly fed induction motor drives, VSI fed poly- phase induction motors.
CO-4	Implement control schemes for PMSM, BLDC and Switched Reluctance Motor drives.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	2	2	2	3	1	1	2	1	2	2	3	2
CO-2	3	3	2	3	3	2	1	2	1	2	2	3	2
CO-3	3	3	2	3	3	2	1	2	1	3	2	3	2
CO-4	3	3	2	3	3	2	1	2	1	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Separately Excited DC-motor Drives: Introduction, Review of DC-motor drives, Speed control of a Separately excited DC motor drive with controlled rectifiers and choppers, Review of controllers, need for anti-windup feature for integral controllers, Speed control of a separately excited DC drive with inner current loop and outer speed loop, Design of current loop with pole- zero cancellation, Design of speed loop with symmetrical optimization technique.

Induction Motor drives: Implementation of V/f control with slip compensation scheme, Review of dq0 model of 3-Ph IM with simulation studies, 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, Control of wound rotor induction machine, introduction to five-phase induction motor drives.

Permanent Magnet Drives: Modelling of Permanent Magnet Synchronous Motor (PMSM) in dq0 reference frame, torque equation, field-oriented control (FOC) for PMSM drive with maximum torque per ampere current mode, modelling of brushless direct current motor (BLDC) drives in dq0 reference frame and torque equation.

Switched Reluctance Motor Drives: Torque expression, converters for SRM drives, Control of SRM drives.

Learning Resources:

Text Books:

1. Modern Power Electronics & AC Drives, B.K. Bose, Pearson Education India, 2015,1st Edition.

2. Electric Motor Drives: Modeling, Analysis and Control; R. Krishnan, Pearson Education India, 2015, 1st Edition.

Reference Books:

1. Bin-Wu, High-power Converters and AC Drives, Wiley-Blackwell, 2017,2nd Edition.
2. M.B. Patil, V. Ramanarayanan, V.T. Ranganathan, Simulation of Power Electronic Circuits, Narosa Publications, 2013.

Other Suggested Readings:

1. nptel.ac.in/courses/108/104/108104140/
2. nptel.ac.in/courses/108/104/108104011/

EE1428 **3-0-0 (3)**

State Space Approach to Control Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Model and analyze the dynamical systems using state space approach
CO-2	Determine the zero state and zero input response using the state equation solution
CO-3	Analyze system properties such as controllability and observability
CO-4	Design the state feedback controller to meet the desired specifications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Dynamical system representation: Classical control review- Linear Time Invariant (LTI) system- Concept of State and State space (SS) approach- State variable selection- Advantages of State space approach- Linearization - Modelling of dynamical systems using SS approach – Different forms of state space representation- Similarity transformation-Invariance of Eigen values- Stability concepts.

State space solution: Solution of the continuous time LTI state equation- Autonomous and Non-autonomous system- Scalar and Matrix cases- State transition matrix (STM) - Important properties of STM- Evaluation methods of the STM- Transfer function from State space model.

Controllability and Observability: Controllability concepts- State controllable and Output controllable- Reachability- Criterion for controllability: Controllability matrix Rank condition, Popov Belevitch Hautus (PBH) criterion- Controllability Gramian –Controllability index- Observability concepts- Constructability- Condition for observability: Observability matrix rank, PBH test- Observability Gramian- Observability index- Pole zero cancellation Vs Controllability and observability

State feedback control : State feedback design for regulator problem - Pole placement approach: Direct substitution, Bass-Gura Approach, Ackermann's formula- Guidelines for desired pole selection- Design of Type-I servo/tracking control: System with Integrator and without integrator- Closed loop stability of system with state feedback controller- Effect of state feedback on Controllability/Observability**.**

State observer based controller design: Need for state observer- Full order observer for regulator problem Observer pole placement methods: Direct substitution, Bass-Gura Approach, Ackermann's formula-- Guidelines for desired observer pole selection- Separation principle- Full order observer for Type-I servo problem- Minimum/reduced order observer design for regulator problem- Separation property- Stability of Observer based control system- Linear quadratic regulator (LQR) problem.

Learning Resources:

Text Books:

1. Chi-Tsong Chen, Linear System Theory and Design, Oxford University Press, Oxford, UK, 2013, 4th Edition.
2. M. Gopal, Modern Control Systems Theory, New Age International, 2014 and 3rd Edition.

Reference Books:

1. K. Ogata, Modern Control Engineering, Pearson Education India, 2015 and 5th Edition
2. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015 and 13th Edition
3. P.J. Antsaklis and A.N. Michel, A Linear Systems Primer, Springer, 2012 and 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/101/108/101108047/

EC1462 **3-0-0 (3)**

VLSI

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the output and transfer characteristics of MOSFET.
CO-2	Analyze the basic semiconductor fabrication process flow.
CO-3	Analyze the static and dynamic characteristics of CMOS circuits.
CO-4	Design combinational circuits and memories.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	3	2	-	2	-	-	-	-	-	1	2	1
CO-2	2	3	2	-	2	-	-	-	-	-	1	2	1
CO-3	2	2	2	-	2	-	-	-	-	-	1	2	1
CO-4	2	2	2	-	2	-	-	-	-	-	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

MOS Transistor Theory: Introduction to metal oxide semiconductor (MOS) structure, Fabrication process flow- basic steps, NMOS/PMOS process, MOSFET, Long channel I-V characteristics, C-V characteristics, non-linear I-V effects, DC transfer characteristics.

MOS Inverter (Static Characteristics & Switching Characteristics): Resistive-load inverter, inverter with n-type MOSFET load, CMOS inverter. Delay-time definitions, calculation of delay times, inverter design with delay constraints, switching power dissipation of CMOS inverters.

Combination CMOS Logic Circuits: MOS logic circuits with depletion NMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic and pass transistor logic circuits.

Memories: SRAM, DRAM.

Learning Resources:

Text Books:

1. Sung-Mo Kang and Yusuf Leblebici, CMOS Digital Integrated Circuit Analysis and Design, McGraw-Hill, 2003, 3rd Edition.
2. N. H. E. Weste and C. Harris, Principles of CMOS VLSI Design: A System Perspective, Pearson Education 2007, 3rd Edition.

Reference Books:

1. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Prentice Hall 2004, 3rd Edition.
2. Fundamentals of Modern VLSI Devices By Yuan Taur, Tak H. Ning · 2021, Cambridge University Press

EE16026 **3-0-0 (3)**

Control and Integration of Renewable Energy Sources

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze different renewable energy sources and storage devices
CO-2	Evaluate renewable energy source models based on simulation results.
CO-3	Simulate control strategies for grid connected and off-grid systems
CO-4	Develop converters to comply with grid standards to obtain grid integration

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	2	2	2	2	3	3	1	2	1	2	3	3	3
CO-2	3	2	3	3	3	3	1	2	1	2	1	3	3
CO-3	3	2	3	3	3	3	1	2	2	1	1	3	3
CO-4	3	2	3	3	3	3	2	1	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies.

Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

Control Issues and Challenges: Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.

Integration of Energy Conversion Technologies: Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC standards for renewable energy grid integrations.

Learning Resources:

Text Books:

1. G. Masters, Renewable and Efficient Electric Power Systems, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. A. Mahaboob Subahani, G. R. Kanagachidambaresan, M. Kathiresh, Integration of Renewable Energy Sources with Smart Grid, Willey 2021.
3. Felix A. Farret, M. Godoy Simoes, Integration of Renewable Sources of Energy, Wiley, 2017, 2nd Edition.

Reference Books:

1. Chetan Singh Solanki, Fundamentals, Technologies & Applications, Solar Photovoltaic, PHI Publishers, 2019, 3rd Edition.
2. Quing-Chang Zhong, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 1st Edition.
3. Bin Wu, Yongqiang Lang, Navid Zargari, Power Conversion and Control of Wind Energy Systems, IEEE- John Wiley and Sons Ltd. Publishers, 2011, 1st Edition.
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, IET Power Electronics Series, 2012.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102145/
2. https://nptel.ac.in/courses/103/103/103103206/

EE16034 **3-0-0 (3)**

Advanced Control Techniques for Power Converters

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze different types of converter model and its usage
CO-2	Design the advanced PID controller with its fractional version and resonant controller for converters
CO-3	Design the robust controller for converter using the loop-shaping methods and the Sliding mode control
CO-4	Design the controller using fuzzy logic and AI techniques for converters and drives

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Modeling of Power converters: Types of Models- Linearized Averaged models- Large signal and Small signal models- Switched models- Relation between various model types- Control goals in converter operation- Review of classical control methods.

Advanced PID controller: PID controller-Tuning methods of PID controller- Set point weighting- Integrator Windup- Controller degrees of freedom- Model based Design methods: Direct Synthesis (DS) method, Internal Model Control (IMC) method- Fractional Control System (FOS) -Design of Fractional PID controller- Case Study: PID controller design for DC-DC boost converter.

Resonant Controller: Necessity of resonant controller- Principle of Proportional Resonant (PR) control- Design methods of PR controller- Example of PR controller design for DC-DC boost converter.

Loop-shaping design: Concept of Loop shaping- Robust controller design using the loop shaping methods: H∞ Control, Quantitative feedback theory (QFT)- Case Study: Loop shaping methods to design the robust controller for DC-DC converter.

Sliding mode controller (SMC): Nonlinear control preliminaries-Types of Uncertainty-Sliding surface design- Stability of SMC- Equivalent control concept- Integral Sliding Mode Control (ISMC) design- Case study: Application of SMC to design the robust controller for DC-DC converter.

Fuzzy logic control and artificial Intelligence (AI) techniques: Introduction to fuzzy logic and AI techniques, application of fuzzy logic to power converters and electric drives, hardware system description, application of AI techniques to electric machines and drives.

Learning Resources:

Text Books:

1. S. Bacha, I. Munteanu, A.I. Bratcu, Power Electronic Converters Modeling and Control with Case Studies, Springer- Verlag London, 2014, 1st Edition.
2. L. Wang, S. Chai, D. Yoo, L. Gan, K. Ng, PID and Predictive Control of Electrical Drives and Power Converters using MATLAB/Simulink Wiley Press, 2015, 1st Edition.
3. A. Mehta, B. Naik, Sliding Mode Controllers for Power Electronic Converters, Springer Nature, 2019.

Reference Books:

1. C. Olalla, Ramon Leyva, I. Queinnec, Robust Linear Control of DC-DC Converters: A Practical Approach to the Synthesis of Robust Controllers, VDM Verlag- Dr. Muller, 2010, 1st Edition.
2. S-C. Tan, Y-M. Lai, C.K. Tse, Sliding Mode Control of Switching Power Converters: Techniques and Implementation, CRC Press, 2012, 1st Edition.
3. Freede Blaabjerg, Control of Power Electronic Converters and Systems, Academic Press, 2018. 1st Edition.
4. Q- C. Zhong, T. Hornik, Control of Power Inverters in Renewable Energy and Smart Grid Integration, Wiley Press, 2013, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/103/108103007/
2. https://nptel.ac.in/courses/101/108/101108047/
3. http://web.mit.edu/nsl/www/videos/lectures.html
4. https://people.ee.ethz.ch/~apnoco/

EE26022 **3-0-0 (3)**

Real-Time Control of Power Systems

Pre-Requisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Analyze real-time operation of power systems.
CO2	Develop mathematical models for State Estimation and Contingency analysis.
CO3	Evaluate the significance of power system security.
CO4	Investigate the optimal location of measurement devices.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

State Estimation of Power System: Introduction to State Estimation (SE) in Power Systems: Weighted Least Square Estimation (WLS-SE). SE of AC networks: Types of measurements, Linear WLS–SE theory, DC Load flow based WLS–SE, Linearized model of WLS–SE of Non–linear AC power systems, typical results of SE on an AC network. Detection and Identification of bad measurements, Network Observability and Pseudo–measurements, optimal meter placement. Incorporation of PMU data in WLS-SE

Security Analysis of Power System: Concept of security, Security analysis and monitoring, Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma based approach, Network Sensitivity factors

Real-Time Control of Power Systems: Introduction, operating states of a Power System

SCADA functions: Introduction to SCADA: Grid Operation & Control, advantages of SCADA operation. Lay out of substation, Main Equipment's in Sub Station, Instrument Transformers, and necessary parameters for Grid operation: Analog Points, Status Points, Alarms, Transducers & their connectivity.

Data Acquisition, Monitoring and Event Processing, Control Functions, Time tagged data, Disturbance data collection and analysis, Reports and Calculations

Human – Machine Interface (HMI): Operator's Console, VDU Display, Operator Dialogs, Mimic Diagram Functions

Remote Terminal Unit (RTU), Phase angle Measurement unit (PMU) & Communication Practices

Major Components: RTU Panel, Interface Panel, D20M Main Processor, Analog Card, Status Card, Control Card, Modems. Types of Communications: Power Line Carrier.

Communications, Microwave, Optical fibre, VSAT Communications. Types of Network Elements in LAN & WAN. Process of Data Communication

Introduction to SCADA protocols and communication standards

Evolution of Protocol for Communication, Protocols -Modbus, Distributed Network Protocol (DNP), IEC 870-5 and 60870 series, IEC-61850, Benefits from IEC (International Electro technical Commission) communication Standards

Load Dispatch Centers: Hierarchy of LDCs, Data Flow, Equipments in LDC: Workstations, FEPS, Routers, Functionalities of Sub LDC-Real time software

Functionalities and operations carried out by Sub LDC, State LDC, Regional LDC and National LDC.

Overview of Computer control of Electrical Power Systems: Evolution of System Control, time scale of system control, online computer control, and Software Elements: State Estimation, Monitoring & Prediction, Generation & Load Control, Security Analysis; Software Coordination & Systems Simulation

Learning Resources:

Text Books:

1. Allen J. Wood, Bruce Wollenberg and Gerald B SheblA, Power System Generation, Operation and Control, John Wiley and Sons, 2013, 3rd Edition.
2. Mini S. Thomas and John D. McDonald, Power System SCADA and Smart Grids, CRC Press, 2015, 1st Edition.
3. Tian Seng Ng, Real Time Power Control Engineering: Systems and Automation Springer, 2016 1st Edition,

Reference Books:

1. John J. Grainger and William D Stevenson Jr, Power System Analysis, McGraw Hill, 2017, ISE.
2. Torsten Cegrell, Prentice, Power System control – Technology, Hall International series in Systems and control Engineering, Prentice Hall International Ltd., 1986.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/108/105/108105133/
2. https://nptel.ac.in/courses/108104191

EE26024 **3-0-0 (3)**

Distribution System Planning and Automation

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Differentiate distribution systems from transmission systems based on their characteristics
CO-2	Evaluate distribution system designs based on forecasted data
CO-3	Select an appropriate substation location based on technical and economic criteria.
CO-4	Evaluate a distribution system for a given geographical service area from alternate design alternatives

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-2	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-3	3	3	3	3	3	1	1	2	1	1	2	3	1
CO-4	3	3	3	3	3	1	1	2	1	1	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Distribution System Planning- Planning and forecasting techniques – Present and future – Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy

Distribution Transformers: Types - Three phase and single phase transformers – connections – causes and types of failures in distribution transformers

Primary distribution systems and Distribution Sub–Stations: Distribution substations –Bus schemes –comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks

Capacitors in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location.

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration –Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions –Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards

Learning Resources:

Text Books:

1. Juan M. Gers, Distribution Systems Analysis and Automation, IET power series, 2020
2. James Northcote-Green, Robert G. Wilson, Control and Automation of Electrical Power Distribution Systems: Taylor & Fransis, 2006
3. A. S. Pabla, Electric Power Distribution, , TMH, 2000

Reference Books:

1. Dr. M.K. Khedkar, Dr. G.M. Dhole,A Textbook of Electric Power Distribution Automation, Laxmi Publications Ltd., 2010
2. Turan Gonen, Electric Power Distribution Engineering, Mc-Graw Hill, 2014

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_ee35

EE26030 **3-0-0 (3)**

Evolutionary Algorithms Applications in Power Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems
CO-2	Examine the importance of exploration and exploitation of evolutionary algorithm to attain near global optimal solution
CO-3	Distinguish the functioning of various evolutionary algorithms
CO-4	Employ various bio-inspired algorithms for Power Engineering applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-2	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-3	3	3	3	3	3	3	1	2	1	2	3	3	3
CO-4	3	3	3	3	3	3	1	2	1	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Soft Computing Techniques- Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

Genetic Algorithm and Particle Swarm Optimization-Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem.

Artificial Bee Colony Algorithm and Differential Evolution - Artificial bee colony (ABC) algorithms-binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch of thermal units. The Motivation for Differential Evolution (DE), Introduction to Parameter Optimization, Single-Point, Derivative-Based Optimization, Local Versus Global Optimization, Differential Mutation, Recombination, Selection, Benchmarking Differential Evolution, DE Versus Other Optimizers, DE on Parallel Processors.

Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm- Bat Algorithm- Echolocation of bats- Behaviour of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs-comparison of memes and genes -memeplex formation- memeple updation- BA and SFLA algorithms for solving ELD and optimal placement and sizing

of the DG problem.

Multi Objective Optimization- Multi-Objective optimization Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution- min-max method-NSGA-II algorithm and applications – Control of Power Converters.

Learning Resources:

Text Books:

1. Xin-She Yang, Recent Advances in Swarm Intelligence and Evolutionary Computation, Springer International Publishing, Switzerland, 2015, 1st Edition.
2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001, 1st Edition.
3. Altaf Q. H. Badar, Evolutionary Optimization Algorithms, CRC Press, 2022

Reference Books:

1. James Kennedy and Russel E Eberheart, Swarm Intelligence , The Morgan Kaufmann Series in Evolutionary Computation, 2001
2. N P Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/112/103/112103301/

Open Electives

EE1473 **2-0-0 (2)**

Classical Control System

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Model and Analyze the dynamical Systems using Transfer Function method.
CO-2	Determine Transient & Steady-State behaviors of dynamical systems.
CO-3	Analyze the steady state errors, absolute/relative stability of dynamical systems in time domain and in frequency domain.
CO-4	Model the dynamical systems using the state space approach.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-2	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-3	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-4	3	3	3	3	3	1	1	2	1	1	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: System, control system, representation of control system types of control systems, Open-loop and closed loop systems, Types of feedback, feedback and its effects, Laplace transform.

Modelling of Dynamical Systems: Mathematical modelling of Electrical and Electro- mechanical systems, Liquid level system, Automotive Systems, Hydraulic systems, Linearization concept.

Techniques to Develop Transfer Function of Systems: Block diagram reduction technique,signal flow graph and Mason's gain formula.

Time Domain Analysis: Test signals, time domain indices, steady state error constants, concept of BIBO stability, absolute stability. Routh- Hurwitz Criterion.

Root Locus Techniques: Introduction, Root loci theory, rules to plot the root locus, applicationto system stability analysis.

State-Space Representation of Dynamical Systems: Importance of States and its advantages, state space representation of dynamical systems.

Frequency Domain Analysis: Introduction, Bode plots, Frequency domain indices, applicationof Bode plots, Polar/Nyquist plots, Principle of PID controller.

Learning Resources:

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 2019, 7th Edition.
2. I.J. Nagarath and M.Gopal, Control Systems Engineering, New Age Pub. Co, 2017, 6th Edition.
3. B.C. Kuo, Automatic Control Systems, Wiley, 2014, 9th Edition.

Reference Books:

1. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 2015, 5th Edition.
2. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015, 13th Edition.
3. K.J. Astrom, R.M. Murray, Feedback Systems- An Introduction for Scientists and Engineers, 2011, 2nd Edition.

Other Suggested Readings:

1. https://www.controleng.com/

EE1475 **2-0-0 (2)**

Swarm Intelligence Techniques

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Analyze the concepts of population-based optimization techniques.
CO-2	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution.
CO-3	Evaluate the importance of parameters in heuristic optimization techniques.
CO-4	Apply meta-heuristic optimization techniques for multi-objective optimization problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-2	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-3	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-4	3	3	3	3	3	1	1	2	1	1	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of soft computing techniques: Definition - Classification of optimization problems, Unconstrained and Constrained optimization Optimality conditions, Introduction to intelligent systems Soft computing techniques, Conventional computing techniques versus Soft computing techniques – Classification of meta-heuristic techniques, Single solution based and population based algorithms, Exploitation and exploration inpopulation based algorithms, Properties of Swarm intelligent Systems – Application domain, Discrete and continuous problems - Single objective and multi-objective problems.

Genetic algorithm and particle swarm optimization: Genetic algorithms - Genetic Algorithm versus Conventional Optimization Techniques, Genetic representations and selection mechanisms, Genetic operators- different types of crossover and mutation operators, Bird flocking and Fish Schooling, Anatomy of a particle - equations based on velocity and positions, PSO topologies - control parameters, Application to SINX maximization problem,

Ant colony optimization and artificial bee colony algorithms: Biologicalant colony system, Artificial ants and assumptions – Stigmergic communications, Pheromoneupdating- local - global - Pheromone evaporation - ant colony system ACO models, Touring ant colony system - max min ant system - Concept of elistic ants, Task partitioning in honey bees - Balancing foragers and receivers – Artificial bee colony (ABC) algorithms - binary ABC algorithms, ACO and ABC algorithms for solving SINX maximization problem.

Shuffled frog-leaping algorithm and bat optimization algorithm: Bat Algorithm - Echolocation of bats - Behavior of microbats - Acoustics of Echolocation, Movement of Virtual Bats - Loudness and Pulse

Emission, Shuffled frog algorithm - virtual population offrogs comparison of memes and genes, Memeplex formation - memeplex updation, BA and SFLA algorithms for solving SINX maximization problem, Application to multi-modal functionoptimization, Introduction to Multi-Objective optimization, Concept of Pareto optimality.

Learning Resources:

Text Books:

1. Xin-She Yang, Recent Advances in Swarm Intelligence and Evolutionary Computation, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Reference Books:

1. N P Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005.

Other Suggested Readings:

1. https://nptel.ac.in/courses/103/103/103103164/
2. https://nptel.ac.in/courses/112/105/112105235/
3. https://nptel.ac.in/courses/106/105/106105173/

EE1477 **2-0-0 (2)**

Entrepreneurial Venture Creation

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Analyze the process and practice of entrepreneurship and new venture creation
CO-2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO-3	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
CO-4	Evaluate the financial, operational, marketing, and organizational aspects of small-scale enterprises.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-2	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-3	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-4	3	3	3	3	3	1	1	2	1	1	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Entrepreneur and Entrepreneurship: Entrepreneurship and Small-Scale Enterprises (SSE); Role in Economic Development, Entrepreneurial Competencies; Institution Interface for SSE

Establishing the small-scale enterprise: Opportunity Scanning and Identification; Market Assessment for SSE; Choice of Technology and Selection of Site; Financing the New/Small Enterprises; Preparation of the Business Plan; Ownership Structures and Organizational Framework

Operating the small-scale enterprises: Financial Management Issues in SSE; Operational Management Issues in SSE; Marketing Management Issues in SSE; Organizational Relations in SSE

Case Studies: Selected Success Stories of Contemporary Entrepreneurs for imbibing positive psychology among the students for launching new ventures.

Learning Resources:

Text Books:

1 New Venture Management: The Entrepreneur's Roadmap, Kuratko, Pearson, 2008.
2 Entrepreneurship: New Venture Creation, Holt, PHI(P) Ltd., 2001.

Reference Books:

1. Madhulika Kaushik, Management of New & Small Enterprises, IGNOU course material, 1995.

2. B S Rathore, S Saini, Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
3. P C Jain, A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
4. J B Patel, D G Allampalli, A Manual on How to Prepare a Project Report, EDII, Ahmedabad, 1991.
5. J B Patel, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

Other Suggested Readings:

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

EE1479 **2-0-0 (2)**

Principles of Electric Power Conversion

Pre-Requisites: None

Course Outcomes (COs):

CO-1	Analyze the fundamentals of electric power conversion using power switching devices.
CO-2	Apply speed control techniques to electrical machines.
CO-3	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives.
CO-4	Analyze different energy storage systems and Industrial & domestic electric power conversion applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PSO-1	PSO-2
CO-1	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-2	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-3	3	3	3	3	3	1	1	2	1	1	2	-	-
CO-4	3	3	3	3	3	1	1	2	1	1	2	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Power electronic devices and converters: V-I Characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

Applications to electric drives: Speed control of DC motor, Induction motors, PMSM and BLDC drives

Applications to renewable energy: Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

Energy storage systems: Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

Domestic and industrial applications: Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers.

Learning Resources:

Text Books:

1. M.H. Rashid, Power Electronics-circuits, Devices and applications, Prentice Hall India, NewDelhi, 2009.
2. P.S. Bhimbra, Power Electronics, Khanna publishers, New Delhi, 2012.

Reference Books:

1. Ned Mohan, Undeland and Robbin, Power electronics converters, applications and design, John Willey & Sons, Inc. New York, 2006.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104140/
2. https://nptel.ac.in/courses/108/105/108105060/

Minor: Electrical Engineering

EE1M01 **3-0-0 (3)**

Electrical Measurement Techniques

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the performance of PMMC, MI, dynamometer & induction type measuring instruments.
CO-2	Determine the circuit parameters using AC and DC bridges.
CO-3	Compute the errors in CTs and PTs.
CO-4	Select transducers to measure temperature, displacement, strain, angular velocity.

Syllabus:

Introduction: Definitions: Accuracy, tolerance, sensitivity, reproducibility, absolute and secondary measuring instruments, recording instruments**.**

Analog Ammeters and Voltmeters: PMMC and MI instruments: construction, torque equation, range extension, advantages and disadvantages.

Analog Wattmeter and Power Factor Meters: Electrodynamometer type wattmeter and power factor meter: construction, working, torque equation, advantages and disadvantages; Measurement of active and reactive power in single phase; Measurement in three phase.

Analog Energy Meter: Single phase induction type energy meters, construction, working, lag adjustments, errors; Maximum demand indicators.

Electrical Bridges: DC bridges: Wheatstone, Kelvin's, Kelvin's double bridge, Megger, Earth resistance measurement; AC bridges: Maxwell's, Anderson, Schering; Applications and limitations.

Instrument Transformers: Construction, working, testing & applications of current transformer and potential transformer.

Transducers: Thermistor, RTD, thermocouple, LVDT, strain gauge, piezoelectric transducers, digital shaft encoders, tachometer, Hall Effect sensors.

Electronic Instruments: Digital voltmeters, Digital Energy Meter, CRO, measurement of voltage and frequency, Lissajous patterns, wave analyzers, harmonic distortion analyzer, LCRQ-meter.

Learning Resources:

Text Books:

1. A. K. Sawhney, A Course in Electrical Measurements, Electronic Measurements and Instrumentation, Dhanpat Rai and Co., 2015.
2. William D. Cooper, Albert D. Helfrick Modern Electronic instrumentation and Measurements Techniques, Prentice Hall of India Pvt. Ltd. 2002.
3. Prithwiraj Purkait, Budhaditya Biswas, Santanu Das, Chiranjib Koley, Electrical and Electronics Measurements and Instrumentation, McGraw Hill Education (India) Private Limited, 2013.

Reference Books:

1. E.W. Golding, F.C. Widdis, Electrical Measurements and Measuring Instruments, Reem Publications, 2011.
2. Ernest O. Doebelin, Measurement Systems-Applications and Design, McGraw-Hill College, 1989, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105153/

EE1M02 **3-0-0 (3)**

Elements of Electrical Power Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the operation of conventional generating stations and renewable sources of electrical power.
CO-2	Apply power tariff methods in power system economic analysis.
CO-3	Identify the types of insulators and their working
CO-4	Evaluate the sustainability and reliability of power systems.

Syllabus:

Introduction: Typical Layout of an Electrical Power System Present Power Scenario in India.

Generation of Electric Power (Qualitative): Conventional Sources: Hydro station, Steam Power Plant, Nuclear Power Plant and Gas Turbine Plant. **Renewable energy Sources:** Wind Energy, Fuel Cells, and Solar Energy, Tidal

Economics of Generation: Introduction, definitions of connected load, maximum demand, demand factor, load factor, diversity factor, Load duration curve, number and size of generator units. Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff on charge to customer.

AC Distribution: Introduction, single line diagram of a typical power system, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, Selection of site and layout of substation,

Overhead Line Insulators: Introduction, types of insulators, Potential distribution over a string of suspension insulators, Methods of equalizing the potential, testing of insulators.

Insulated Cables: Introduction, insulation, insulating materials, Extra high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables.

Sustainability of Power System: environmental sustainability, economic sustainability, social sustainability, concept of power system reliability

Technology Drivers (Qualitative): Technologies associated with Distributed energy Resources (e.g. Fuel cells, Microturbines, Solar PV)

Learning Resources:

Text Books:

1. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New-Age International, 2009, 2nd Edition.
2. C.L. Wadhwa, Electrical Power Systems, New-Age International, 2009, 5th Edition.
3. W.D. Stevenson, Elements of Power System Analysis, McGraw Hill, 1984, 4th Edition.

Reference Books:

1. Nava Raj Karki, Rajesh Karki, Ajit Kumar Verma, Jaeseok Choi, Sustainable Power Systems, Springer Singapore, 2017.
2. Lingfeng Wang, Modeling and Control of Sustainable Power Systems, Springer-Verlag Berlin Heidelberg, 2012.
3. M.V. Deshpande, Elements of Electrical Power Station Design, Wheeler Pub.1998, 3rd Edition.

Other Suggested Readings:

1. https://www.coursera.org/learn/electric-power-systems
2. https://onlinecourses.nptel.ac.in/noc19_ee62/preview

EE1M03 **3-0-0 (3)**

Power Converters and Applications

Pre-Requisites: None

Course Outcomes:

CO-1	Select switching devices for a given power converter.
CO-2	Evaluate the performance of phase-controlled rectifiers.
CO-3	Identify and design DC-DC converter for a given application.
CO-4	Analyze & evaluate the Inverters and ac voltage controllers for a given application.

Syllabus:

Introduction: Concept of power electronics, scope and applications, types of power converters, power semiconductor switches and V-I characteristics: Diodes, SCR, TRIAC, power MOSFET, IGBT devices and applications. Line commutation of SCR, gate drive circuit.

Phase-Controlled Rectifiers: Principles of single-phase full- & half-controlled converter with R, RL, and RLE load, Principles of three- phase fully controlled converter operation with RLE load, and applications.

DC-DC Converters: Introduction, chopper classification of choppers, Basic principles of step-down and step-up operation, study of Buck, Boost and Buck-Boost converters and applications.

Inverters: Introduction, principle of operation, performance parameters, single phase bridge inverters with R, RL and RLC loads, 3-phase bridge inverters-180 and 120 degrees mode of operation, voltage control of single phase inverters-single pulse width modulation, sinusoidal pulse width modulation and applications.

A.C. Voltage Controllers: Introduction, principle of operation of single-phase voltage controllers for R, R-L & R-L-E loads and applications.

Learning Resources:

Text Books:

1. M.H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson Education; 28 November 2017, 4th Edition.
2. L. Umanand, Power Electronics: Essentials & Applications, Wiley publishers, Kindle Edition, 1 January 2009.

Reference Books:

1. Philip T. Krein, Elements of Power Electronics, Oxford University Press, Indian Edition, 1 November 2017, 2nd Edition.
2. Mohan Undeland Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2006.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/101/108101038/

EE1M04 **3-0-0 (3)**

Industrial Applications of Electrical Energy

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the basic principles of electric heating and welding.
CO-2	Determine the lighting requirements for flood lighting, household and industrial needs
CO-3	Estimate heat developed in induction furnace.
CO-4	Evaluate power requirement in electrolytic processes & speed time curves for traction.

Syllabus:

Illumination Science: Laws of illumination, coefficient of Utilization and depreciation, Polar curves, photometry, integrating sphere, sources of light, fluorescent lamps, compact fluorescent lamps, LED lamps discharge lamps, mercury vapour lamps, sodium vapour lamps and neon lamps, comparison between tungsten filament lamps and fluorescent tubes. Basic principles of light control, Types and design of lighting scheme, lighting calculations, factory lighting, street lighting and flood lighting.

Electric Heating: Principles of Electric Heating, Various Schemes and methods of Resistance heating- Direct and Indirect heating, Induction heating, Dielectric heating and Microwave heating. Applications of Heating and modern heating methods. Simple problems.

Electric Arc Welding: Electric welding equipment, resistance welding and arc welding, comparison between AC and DC welding.

Electrolytic Process: Basic principles, Faraday's law of Electrolysis, Electro deposition, Extraction and refining of metals, Power supply of Electrolytic processes.

Electric Traction: Systems of electric traction and track electrification- DC system, single phase and 3-phase low frequency and high frequency system, composite system, kando system, comparison between AC and DC systems, problems of single-phase traction with current unbalance and voltage unbalance. Systems of train lighting, special requirements of train lighting, methods of obtaining unidirectional polarity constant output- single battery system, Double battery parallel block system, coach wiring, lighting by making use of 25 kV AC supply, Speed control of Traction motors(DC Series motors) series-Parallel connection, Shunt Transition, Bridge Transition. Problems on series-parallel control.

Learning Resources:

Text Books:

1. H. Partab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Sons, 2017.
2. H. Partab, Modern Electric Traction, Dhanpat Rai & Co, 2017.
3. E. Openahaw Taylor, Utilisation of Electric Energy, Orient Longman, 1971.

Reference Books:

1. C.L. Wadhwa, Generation Distribution and Utilization of Electrical Energy, New Age International Publishers, 2017, 3rd Edition.

2. N.V. Suryanarayana, Utilisation of Electrical power including Electric drives and Electric Traction, New Age Publishers, 2017, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105060/
2. https://www.youtube.com/watch?v=mX8k3xrOXwg

EE1M05 **3-0-0 (3)**

Elements of Smart Grid Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the features of Smart Grid
CO-2	Assess the role of digitization in Transmission and Distribution
CO-3	Analyze Smart grids and Distributed energy resources (DER) with evolutionary algorithms
CO-4	Investigate the importance of data acquisition devices in smart grids.

Syllabus:

Introduction: Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, Role of non-conventional Energy sources in smart grid, smart-grid activities in India.

Smart Grid Architecture and elements: Smart grid architecture, power line communications, supervisory control and data acquisition system (SCADA), advanced metering infrastructure (AMI).

Advanced Electricity pricing- Demand Response.

Clean and Green Energy Sources: Introduction to Distribution Energy Sources, Renewable Energy Technologies – Microgrids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

Smart Grid Communication: Introduction to Communication Technology, Synchro- Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)-

Introduction to Internet of things (IoT)- Applications of IoT in Smart Grid.

Smart-cities: Smart city pilot projects, essential elements of smart cities, active distribution networks,

Computational Tools for Smart Grid: Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch – Artificial Intelligence techniques and applications in power system. Evolutionary Algorithms in power system.

Learning Resources:

Text Books:

1 Krishan Arora, S Lata Tripathi, S Padmanaban, Smart Electric Grid systems: Design Principle, Modernization and Techniques, CRC Press, New York, 2023.
2 K S Manoj, Smart Grid: Concepts To Design, Kindle edition, 2019.

Reference Books:

1. A.G. Phadke and J.S. Thorp, Synchronized Phasor Measurements and their Applications, Springer, 2017, 2nd Edition.
2. T. Ackermann, Hoboken, Wind Power in Power Systems, N J, USA, John Wiley, 2012, 2nd Edition.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc23_ee60/preview
2. https://onlinecourses.nptel.ac.in/noc21_ee68/preview
3. https://www.coursera.org/lecture/electric-power-systems/smart-grid-utilities-consumers- TSfBn

Honors: Electrical & Electronics Engineering

EE16028 **3-0-0 (3)**

High Power Inverters

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the Weighted THD and implement SVM based on instantaneous phase reference voltages
CO-2	Implement level-shifted, phase-shifted, hybrid and Space Vector PWM schemes for Cascaded H-Bridge Multilevel Inverters
CO-3	Develop PWM schemes to balance the neutral point, eliminate common mode voltage and reduce the switching power loss in diode clamped multilevel inverter
CO-4	Develop reduced switch count MLIs and PWM current source inverters

Syllabus:

Introduction: Review of two-level inverters and their PWM schemes. Effect of dead-time and compensation in two-level inverters. Limitations of two-level inverters and introduction to multilevel inverters. Conventional multilevel inverter topologies.

Diode clamped multilevel inverter (DCMLI): 3, 4 and 5 level DCMLIs, level-shifted PWM, Neutral point voltage balance, SVM and discontinuous SVM, Elimination of common mode voltage, Active Neutral Point Clamped Inverter (ANPCI).

Cascade H-bridge (CHB) multilevel inverter (MLI): Symmetrical and asymmetrical topologies, level-shifted PWM, phase-shifted PWM, hybrid PWM and SVM. Concept of coupling transformer-less grid connected applications, Topologies of modular multilevel inverters (MMI).

Reduced switch count MLIs: Introduction, classification, operation of T-type, multilevel dc link, switched series parallel source and other topologies.

PWM current source inverters: Trapezoidal modulation, selective harmonic elimination and SVM, Load-commutated inverters (LCI).

Learning Resources:

Text Books:

1. Bin Wu, High Power Converters and AC Drives, Wiley-Inter science, 2017, 2nd Edition.
2. D. Grahame Holmes, Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, Wiley-IEEE Press, 2003.

Reference Books:

1. Research Publications.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102157/

EE46024 **3-0-0 (3)**

Digital Control Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Model the discrete time (DT) system in state space form
CO-2	Perform the stability analysis for DT dynamical system
CO-3	Design the state feedback control for DT system
CO-4	Formulate and solve the DT optimal control problems

Syllabus:

Introduction: Continuous and Discrete time system-Digital control systems - Quantizing and quantization error, Sampling theorem.

Z-Transform: Z-transforms of elementary functions, important properties and theorems, Inverse Z-transform, Z-transform method of solving difference equations.

Z-Plane Analysis of Discrete-Time Control Systems: Impulse sampling and data hold, Pulse transfer function, Realization of digital controllers and digital filters, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in z-plane, Transient and steady state analyses.

State Space Analysis of digital control systems: Solution of discrete time state space equations, Discretization of continuous time state space equations, Lyapunov stability analysis for Discrete linear system, Controllability, Observability, Pole Placement and Observer Design.

Discrete Optimal Control Systems: Linear Quadratic Regulator (LQR) Design via pole placement, Steady state quadratic optimal control.

Learning Resources:

Text Books:

1. K. Ogata, Discrete time control systems, Pearson Education India, 2015, 2nd Edition.
2. M. Gopal, Digital Control and State Variable Methods, McGraw Hill Education, 2017, 4th Edition.

Reference Books:

1. C.L. Phillips, H.T. Nagle, A. Chakrabortty, Digital Control System Analysis and Design, Pearson, 2014, 4th Edition.
2. B.C. Kuo, Digital Control Systems, Oxford University Press, 2012, 2nd Edition.
3. C.A. Rabbath, N. Lechevin, Discrete-Time Control System Design with Applications, Springer-Verlag New York Inc, 2014, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105186
2. https://nptel.ac.in/courses/108103008

EE16027 **3-0-0 (3)**

Power Quality Improvement Techniques

Pre-Requisites: None

Course Outcomes:

CO-1	Identify power quality problems in distribution system
CO-2	Evaluate power quality indices in distribution system
CO-3	Develop mitigation techniques for compensating devices to improve power quality in distribution system
CO-4	Suggest compensating devices to improve power quality in distribution system

Syllabus:

Power Quality: Significance of power quality, Power quality terms: Transients, Long- duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuation, CBEMA and ITI curves. Devices for Overvoltage Protection: Surge arresters and transient voltage surge suppressors, Isolation transformers and Low-impedance power conditioners.

Waveform Distortion: Introduction, Voltage versus current distortion, Harmonics versus transients, Harmonics indices: Total Harmonics Distortion (THD) and Total Demand distortion (TDD); Harmonic standards; Harmonic analysis; Harmonic phase sequence; Triplen harmonics; Interharmonics.

Harmonic Sources: Introduction; Harmonics generated from electrical machines such as transformers and rotating machines; Arcing devices; Static power conversion: Phase controlled and uncontrolled rectifiers, AC voltage regulators, Pulse width modulated inverters; Converter fed ac and dc drives.

Effects of Harmonic Distortion: Introduction; Resonances; Effects of harmonics on rotating machines; Effect of harmonics on static power plant; Power assessment with distorted waveforms; Effect of harmonics on measuring instruments; Harmonic interference with ripple control systems; Harmonic interference with power system protection; Effect of harmonics on consumer equipment; Interference with communication systems.

Harmonic Elimination: Introduction; Passive power filters: Design, A Shunt active power filters: Configurations, State of the art, Design and control strategies. Three-phase four-wire shunt active power filters

Voltage Quality: Introduction; Sources of Sags, Swell, Unbalance and Flicker; Voltage quality standards; Effects of sags, Swell, Unbalance and Flicker; Voltage sag magnitude due to fault; Voltage sag magnitude calculation based on influence of cross section of conductor, transformer and fault levels; Critical distance for a voltage sag magnitude; Causes of phase-angle jumps in voltage; Classification of voltage sags, voltage sag transformation due to transformers.

Methods for improving Voltage Quality: Introduction; Dynamic Voltage Restorer (DVR): Operating principle, Configurations, State of the art, Design and control strategies. Three-phase four-wire DVR.

Unified Power Quality Conditioner (UPQC): Introduction; design and control; Three- phase three-wire UPQC and three-phase four-wire UPQC topologies, Multilevel inverters based UPQC topologies, Mitigation of Flicker.

Learning Resources:

Text Books:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, Wiley, 2015.
2. Math H. J. Bollen, Understanding power quality problems, Wiley-IEEE Press, 2000, 1st Edition.
3. Mahesh Kumar Mishra, Power Quality in Power Distribution Systems Concepts and Applications, CRC Press, 2023.

Reference Books:

1. Ghosh Arindam, Ledwich Gerard, Power Quality Enhancement Using Custom Power Devices, Springer, 2009.
2. Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Wiley-IEEE Press, 2017.
3. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, Electrical Power Systems Quality, McGraw Hill, 2012, 3rd Edition.
4. J. Arrillaga, N.R. Watson, Power System Harmonics, Wiley, 2003, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/107/108107157/
2. https://nptel.ac.in/courses/108/106/108106025/

EE26001 **3-0-0 (3)**

Advanced Computational Methods in Power Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Develop mathematical models for load flow studies for Transmission and Distribution systems and Fault analysis
CO-2	Prepare the input data required for load flow analysis and fault calculations
CO-3	Apply appropriate algorithms for load flow studies
CO-4	Develop power system software /implementation of algorithm for static power system studies

Syllabus:

Network Matrices: Concept of incidence matrix, formation of A and Â matrices, list of other types of incidence matrices and their limitations. Representation of Generator, Transmission lines and Transformers, Primitive and Network matrices, Ybus formation by Inspection method and its algorithm. Merits and Demerits of Ybus and Zbus matrices in Power System Analysis – Areas of application

Introduction to Load Flow Analysis: Y-bus based Power System Static Load Flow Equations. Gauss-Seidel (GS) method, PV-bus treatment, Gauss-Seidel load flow algorithm. Need of Sparsity technique for 'well-grown' power systems, Concept of Sparsity technique, Y-bus formation using Sparsity technique. GS with Sparsity technique, Merits and Demerits of GS method

Newton-Raphson (NR) load flow method: and its algorithm. Merits and Demerits of NR method; Newton's Decoupled, Fast Decoupled equation, algorithm of Fast Decoupled (FDC) method. Merits and Demerits of FDC method; Areas of application of load flow study. AC/DC load flow solutions

Distribution system Load Flow methods: Vector based load flow method, Backward-Forward Sweep method and Current injection method

Load flow studies with Renewable Energy Sources: Solar and Wind Energy Sources. Need of short circuit studies – Assumptions in short circuit studies – Areas of application

Formation of Z-bus: using step-by-step approach (Addition of a branch & Addition of a link). Modification of Zbus elements for changes

Symmetrical Sequence Components: significance of symmetrical components, approximations, formation of primitive z^{abc}, y^{abc}, z^{012} and y^{012} for various types of faults

Formation of $Zbus^{012}$: by step-by-step algorithm. Derivation of relevant equations for E^{012} for LLLG and LG faults

Learning Resources:

Text Books:

1. Stagg and El–Abiad, Computer Methods in Power System Analysis, Medtech scientific international, 2019.
2. M A Pai and Dr. Dheeman Chatterjee, Computer techniques in Power System Analysis, McGraw hill, 2014.

3. Mariesa L Crow, Computational Methods for Electric Power Systems (Electric Power Engineering Series), Taylor and Francis, 2015.

Reference Books:

1. Hadi Sadat, Power System Analysis, McGraw Hill – International Edition – 2019.
2. J. Arrilaga and NR Watson, Computer Modeling of Electrical Power Systems, John Wiley and Sons, 2010, 1st Edition.
3. Dipu Sarkar, Chandan Kumar Chanda, Abhinandan De ,Computational Techniques for Power Systems Analysis Perfect , BSP Books Pvt. Ltd 2024.

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/117/105/117105140/
2. https://nptel.ac.in/courses/108104051
3. https://nptel.ac.in/courses/101104086

EE26002 **3-0-0 (3)**

Digital Protection of Power Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Recognize the advantages of digital relays over conventional relay
CO-2	Apply the suitable signal processing techniques for protection
CO-3	Analyze the adaptive criterion for relay decision making
CO-4	Identify the new developments in protective relaying and applications

Syllabus:

Overview: Static relays Transmission line protection, Transformer protection, Need for digital protection

Introduction to Digital Sub-stations

Digital Relays: Basic elements of a digital relay and their functions, signal conditioning subsystem, conversion subsystem, digital relay subsystem

Signal processing techniques: Sinusoidal based algorithms, Fourier analysis-based algorithms, Least squares based algorithm, Discrete Fourier Transforms, Wavelet Transforms, Kalman Filtering

Protection Schemes: Travelling Wave Protection scheme, Digital Protection of Transformers, Infinite Impulse Response Filters, Finite Impulse Response filters.

Correction of errors introduced by Instrument Transformers: PTs and CTs, detection of unsaturated fragment of wave shape, CT saturation correction procedure.

Decision making in Protective Relays: Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criterions, Adaptive decision schemes, Adaptive Differential protective scheme.

Applications: Fuzzy Logic and ANN for power system protection, Fault location algorithm, Wide Area Monitoring and Protection.

Learning Resources:

Text Books:

1. A.G. Phadke, James S.Thorp, Computer Relaying for Power Systems, John-Wiley and sons, 2009, 2nd Edition.
2. Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, Digital Signal Processing in Power System Protection and Control, Springer Publication, 2011, 1st Edition.
3. Johns, Digital Protection for Power Systems, IET Power Series, 2012.

Reference Books:

1. Singh, Digital Power System Protection, Prentice-Hall of India Pvt. Limited, 2007, 1st Edition.
2. Orhan Gazi, Understanding Digital Signal Processing, Springer, 2017, 2nd Edition.
3. Y.G. Paithankar, Fundamentals of Power System Protection, PHI, 2010, 2nd Edition.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc20_ee73
2. https://archive.nptel.ac.in/courses/117/107/117107148
3. https://onlinecourses.nptel.ac.in/noc22_ee46