CURRICULUM & SYLLABI

B.Tech. Electrical and Electronics Engineering (Electric Mobility)

Effective from AY: 2026-27



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 stakeholders 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 (Electric Mobility)

Program Educational Objectives

PEO-1	Design, develop, innovative electrical and electronic products and services for electric mobility, energy storage, and sustainable transportation systems.
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 (Electric Mobility)

Program Outcomes

PO-1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, Engineering fundamentals, and Electrical Engineering to the solution of complex engineering problems in electrified transportation, energy storage.
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 Teamwork:** 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 and 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 sustainable and energy-efficient electrical and electronic equipment and systems to enhance the quality of human life.
PSO-2	Develop innovative and environment–conscious electrical and electronic technologies, particularly in electric mobility and advanced energy storage systems to sustain human life.

CURRICULUM
B.Tech. Electrical and Electronics Engineering (Electric Mobility)

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	EE2102	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	EE2201	Electrical Measurements and Safety	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	EE2202	Power Generation and Transmission	3-1-0	4
3	EE1206	Control Systems	3-0-0	3
4	EE1212	Artificial Intelligence and Machine Learning	2–0–2	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		**20**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE2301	Elements of E-Mobility	3-0-0	3
2	EE2303	Power Converters for E-Mobility	3-0-0	3
3	EE2305	Microcontrollers and Digital Signal Processors	3-1-0	4
4	EE2307	Operation and Control of Power Systems	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	EE2381	Fractal Course - I	1-0-0	1
			Total Credits	**21**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE2302	FPGA Design	3-0-0	3
2	EE2304	Battery Management System	3-0-0	3
3	EE23XX	Program Elective – I	3-0-0	3
4	EE23XX	Program Elective – II	3-0-0	3
5	EE2306	Product Development	0-1-4	3
6	EE2308	EV & Charging Infrastructure Lab	0-1-2	2
7	EE2310	Microcontrollers and DSP Application Lab	0-1-2	2
8	EE2382	Fractal Course – II	1-0-0	1
			Total Credits	**20**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE2401	Motor Drives for EV	3-0-0	3
2	EE24XX	Program Elective – III	3-0-0	3
3	EE24XX	Program Elective – IV	3-0-0	3
4	EE24XX	Open Elective	2-0-0	2
5	EE2403	Power Converters & Drives Lab for E-Mobility	0-1-2	2
6	EE1409	Power Systems Lab	0-1-2	2
7	EE2489	Seminar & Technical Writing	0-0-0	2
8	EE2491	Short Term Industrial/EPICS/Research Experience	0-0-0	2
9	EE2495	Minor Project	0-0-0	2
		Total Credits		**21**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	EE24XX	Program Elective – V	3-0-0	3
2	EE24XX	Program Elective – VI	3-0-0	3
3	EE24XX	Program Elective – VII	3-0-0	3
4	EE2498	Major Project	0-0-0	6
		Total Credits		**15**

Program Elective Courses

Program Elective – I & II		
Sl. No.	**Code**	**Course Title**
1	EE2322	Advanced Power Electronic Converters for E-Mobility
2	EE2324	Safety and Testing for Electric Vehicles
3	EE2326	Thermal Management in EVs
4	EE2328	Switchgear and Protection
5	EE1330	Modelling & Analysis of Electrical Machines
6	EE1334	Utilization of Electrical Energy
7	EE2330	Vehicle Frames and Structures for E-Mobility
8	EE1338	IoT in Electrical Engineering
9	EE1340	Special Machines
10	EE1342	Python Programming
11	EE1344	Energy System Analytics
12	EC1364	Synthesis of Digital Systems

Program Elective – III & IV		
S.No.	**Code**	**Course Title**
1	EE2421	Renewable Energy Sources
2	EE2423	EV Embedded Systems & Communication
3	EE2425	Autonomous driving in E-Mobility
4	EE1421	Switched Mode Power Conversion
5	EE1423	Planning an Entrepreneurial Venture
6	EE1427	Power Quality
7	EE1429	Quantum Computing Techniques in Electrical Engineering

Program Elective – V, VI &VII		
Sl. No.	**Code**	**Course Title**
1	EE2422	Manufacturing Technologies for E-Mobility
2	EE2424	Applications of AI for E-Mobility
3	EE2426	Electric Vehicle Charging Infrastructure
4	EE2428	Machine Design for E-Mobility
5	EE1426	Advanced Electrical Drive Systems
6	EE1428	State Space Approach to Control Systems
7	EC1462	VLSI
8	EE16026	Control and Integration of Renewable Energy Sources
9	EE16034	Advanced Control Techniques for Power Converters
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	95
Program Elective	21
Open Elective	2
Total Graded Credit Requirement	153

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 (Electric Mobility)

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 and minima 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	Evaluate 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/

EE2102 **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
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 heat conduction 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/

EE2201 **3-0-2 (4)**

Electrical Measurements and Safety

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze electrical measurement principles, instruments, bridges and instrument transformers
CO-2	Apply transducers and electronic instruments in electric vehicle measurements
CO-3	Analyze smart instruments, energy meters and AMR/AMI systems
CO-4	Evaluate electrical safety practices and standards in EV 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	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 and electrodynamometer type instruments: construction, working, types, range extension, errors, advantages and disadvantages

DC & AC bridges: Introduction to bridge circuits; Wheatstone bridge, Kelvin's bridge, megger, Maxwell's bridges, Schering bridge; limitations and applications.

Instrument Transformers: Construction, types, working, errors, testing and applications.

Electronic instruments: Introduction to digital instruments, structure, types, sensitivity and detection of signals; digital voltmeters, LCR meter.

Transducers and Smart instruments: Classification, types, thermistor, RTD, thermocouple, LVDT, strain gauge, piezoelectric transducers, digital shaft encoders, tachometer, Hall effect sensors; applications, Intelligent transducer, self-diagnosis and remote calibration features, smart energy meter components, working principle; Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI) environments.

Electrical Safety in EV Systems: High-voltage DC hazards in electric vehicles, orange cable standards, insulation monitoring devices (IMDs), grounding and isolation techniques and measuring instruments, arc flash in DC systems, PPE requirements, leakage protection using Type-B RCDs, High Voltage Interlock Loop (HVIL), automatic disconnect systems and emergency shutdown mechanisms; EMI/EMC issues and signal integrity measurements in EV powertrain systems, battery thermal runaway and fire safety, Class-D fire extinguishers, overview of AIS-156 and ISO 26262 standards.

Learning Resources:

Text Books

1. A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2019, 19th Edition.
2. E. W. Golding, F. C. Widdis, Electrical Measurements and Measuring Instruments, Reem Publications Pvt. Ltd., Reprint Edition, 2011.
3. Albert D. Helfrick, William D. Cooper, Modern Electronic instrumentation and Measurements Techniques, Pearson Education India, Reprint Edition, 2015.

Reference Books:

1. Ernest O. Doebelin, Dhanesh N. Manik, Measurement systems, McGraw Hill India, 2019, 7th Edition.
2. R. K. Rajput, Electrical and Electronic Measurements and Instrumentation, S. Chand & Co. Ltd., 2015, 4th Edition.
3. H S Kalsi, Electronic Instrumentation and Measurements, McGraw Hill, 2019, 4th Edition.
4. John Cadick, Electrical Safety Handbook, McGraw Hill, 2012, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105153

EE2201 **0-0-2 (1)**

Electrical Measurements and Safety Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Demonstrate the measurement of current, voltage, power, temperature and frequency.
CO-2	Measure the torque and speed of rotating machines using various PWM techniques.
CO-3	Measure the high voltage insulation resistance.
CO-4	Measure the EMI/EMC in electric vehicles.

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. Measurement of temperature using a thermistor and plot its characteristics.
2. Torque and speed measurement for rotating machines and plot its characteristics.
3. Isolation Testing: Measure insulation resistance of a motor winding using a Megger and earth resistance measurement.
4. HVIL Simulation: Test the automatic shutdown of a circuit when a connector is unplugged.
5. Generation of PWM signals and analyze it.
6. BMS Calibration: Calibrate current sensors to ensure accurate SoC readings.
7. EMI/EMC testing between powertrain and vehicle sensors.
8. Charging Faults: Simulate a "Pilot Signal" loss to observe charging cut-off behavior.

Learning Resources:

Text Books

1. A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2019, 19th Edition.
2. E. W. Golding, F. C. Widdis, Electrical Measurements and Measuring Instruments, Reem Publications Pvt. Ltd., Reprint Edition, 2011.

Reference Books:

1. Ernest O. Doebelin, Dhanesh N. Manik, Measurement systems, McGraw Hill India, 2019, 7th Edition.
2. R. K. Rajput, Electrical and Electronic Measurements and Instrumentation, S. Chand & Co. Ltd., 2015, 4th Edition.
3. John Cadick, Electrical Safety Handbook, McGraw Hill, 2012, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105153

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 amplifier
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.

~~**COS are similar to theory**~~

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/

EE2202 **3-1-0 (4)**

Power Generation and Transmission

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the structure of modern electric power systems and power generation technologies.
CO-2	Analyze transmission line parameters and transmission line performance.
CO-3	Evaluate voltage control and reactive power compensation methods in power systems.
CO-4	Apply symmetrical components to perform fault analysis in 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	2	2	1	1	1	1	1	2	2	2	3	2
CO-2	3	3	2	2	2	1	1	1	2	2	2	3	3
CO-3	3	3	3	2	2	1	1	1	2	2	2	3	3
CO-4	3	3	3	3	2	1	1	1	2	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Electric Power Systems: Structure of modern electric power systems, conventional generation (thermal, hydro, nuclear, gas turbine), renewable generation (solar, wind), economics of generation, load curves, demand factor, diversity factor, base load and peak load plants.

Transmission Line Parameters and Modelling: Transmission line parameters (R, L, C), inductance and capacitance calculations, effect of conductor spacing and bundled conductors, Performance analysis of short, medium and long transmission lines models, ABCD parameters, Ferranti effect, sag and tension calculations.

Insulators, Cables and Corona: Types of overhead line insulators, potential distribution in suspension insulators, underground cables (construction, insulation materials), capacitance and insulation resistance of cables, corona phenomenon, corona loss and reduction techniques.

Per Unit System: Single line diagram, impedance diagram, per-unit system, base change, advantages of per-unit representation.

Voltage Control and Reactive Power Compensation: Voltage regulation of transmission lines, reactive power concepts, shunt compensation (capacitors/reactors), series compensation, tap-changing transformers, synchronous condensers, power factor correction.

Symmetrical Components and Fault Analysis: Symmetrical components, sequence networks, positive, negative and zero sequence components, symmetrical fault analysis, unsymmetrical faults (LG, LL, LLG) and fault current calculations.

Learning Resources:

Text Books

1. C. L. Wadhwa, Electrical Power Systems, New Age International, 4th Edition, 2006.
2. D. P. Kothari & I. J. Nagrath, Modern Power System Analysis, McGraw-Hill, 5th Edition, 2022.
3. Stevenson, Power System Analysis, McGraw-Hill Science Engineering, 1st Edition, 1994.

Reference Books:

1. Allen J. Wood & Wollenberg, Power Generation, Operation and Control, Wiley-Interscience, 2nd Edition, 1996.
2. A. Chakrabarti, M.L. Soni, P.V. Gupta, U.S. Bhatnagar, Power System Engineering, Dhanpat Rai Publishing Company (P) Ltd, 2009 Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105104

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 linear 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.

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

EE2301 **3-0-0 (3)**

Elements of E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the concepts of E-Mobility
CO-2	Analyze electric drive topologies for electric vehicle applications.
CO-3	Apply the principles of fast charging and communication protocols to electric vehicles.
CO-4	Evaluate the suitability of various energy storage elements for E-mobility.

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

Syllabus:

Introduction to EV Technologies: Evolution of electric vehicles, types of electric vehicles (BEV, HEV, PHEV and FCEV), EV architectures, vehicle classification, environmental impact of EVs, usage patterns, standards and regulations for e-mobility, government policies, basics of vehicle aerodynamics, battery management system (BMS) and EV safety fundamentals.

Hybrid and Electric Drive-trains: Basic concept of traction, hybrid and electric drive-train topologies, power flow in drive-train systems, introduction to electric propulsion systems, overview of DC motor, induction motor, permanent magnet motor and switched reluctance motor drives, drive system efficiency.

Modelling of BEV: Forward looking Model-Driver Perspective, Backward Looking Model-Drive Cycle Perspective, Modelling of Driver, Modelling of Brake Control Unit, Modelling of Vehicle Control Strategy, and Modelling of Vehicle Chassis.

Sizing of Components: Steady State Energy Balance Equation, Powertrain Dimensioning-Peak vs Continuous performance, Type of Drive cycles, Types of Control Strategy, Analysis-Performance, Range, and Consumption Prediction. Safety and security aspects of EV.

Charging Infrastructure and Communication: AC and DC charging systems, communication architecture for DC fast charging, EV-grid connectivity, charging protocols, utility interface requirements for EV charging, charging infrastructure and safety aspects.

Policies, Standards and Safety: Policies and incentives for EV adoption, standards and regulations for charging infrastructure, electrical safety and security aspects of EVs, battery safety, thermal management and protection systems.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, Fuel Cell, Super, Flywheel - Hybridization of different energy storage devices.

Learning Resources:

Text Books:

1. Iqbal Husain, Electric and Hybrid Electric Vehicles: Design Fundamentals, CRC Press, 2021, 3rd Edition.

2. Mehrdad Ehsani, Yimin Gao and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2018, 3rd Edition.
3. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, 2012, 2nd Edition.

Reference Books:

1. Chris Mi, M. Abul Masrur and David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2017, 2nd Edition.
2. Gregory L. Plett, Battery Management Systems, Artech House, 2015, 1st Edition.
3. Lino Guzzella and Antonio Sciarretta, Vehicle Propulsion Systems, Springer, 2021, 4th Edition.
4. C. C. Chan and K. T. Chau, Modern Electric Vehicle Technology, Oxford University Press, 2001, 1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108106170
2. https://nptel.ac.in/courses/108104140

EE2303 **3-0-0 (3)**

Power Converters for E-Mobility

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 criteria.
CO-4	Analyze inverter operation, modulation techniques, and soft-switching converters.

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: Power Diodes, SCRs, Power MOSFETs, and Power IGBTs, Gate drive circuits, switching, and conduction losses in a generic power semiconductor device, Wide Bandgap switching devices (SiC and GaN), performance and advantages.

AC-DC Converters: Principles of single-phase and three-phase fully controlled rectifiers, effect of source inductances, Principles of Active Front End converters and their role in Power Factor Correction, Single phase and Three phase dual converters

DC-DC Converters: Introduction, Basic principles of step-down and step-up operation, chopper classification, Non-Isolated Converters: Buck, Boost and Buck-Boost regulators, Continuous and Discontinuous mode of operation, Isolated converters: Forward, Fly-back, Push-pull and Full-bridge 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, Introduction to Space Vector PWM concepts

Soft-Switching & Resonant Converters:
Introduction to hard switching and soft switching, Basic principles of Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS), Introduction to series and parallel resonant converters, Basic principles of Inductive Power Transfer (IPT) for Wireless EV Charging systems.

Learning Resources:

Text Books:

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

2. Ned Mohan, T M Undeland, W P Robin, Power Electronics - Converters, Applications and Design, John Wiley & Sons, 2002, 3rd Edition.
3. Robert W. Erickson and Dragan Maksimović, Fundamentals of Power Electronics, Springer, 2020, 3rd Edition.

Reference Books:

1. P. S. Bimbhra, Power Electronics, Khanna Publishers, 2016, 6th Edition.
2. Marian K. Kazimierczuk, Pulse-Width Modulated DC-DC Power Converters, Wiley, 2015, 2nd Edition.
3. B. Jayant Baliga, Wide Bandgap Semiconductor Power Devices, Woodhead Publishing, 2018, 1st Edition.
4. Andrzej Trzynadlowski, Introduction to Modern Power Electronics, Wiley, 2015, 2nd Edition.

Other Suggested Readings:

1. https://ocw.mit.edu/courses/6-622-power-electronics-spring-2023/
2. https://nptel.ac.in/courses/108101038
3. https://nptel.ac.in/courses/108106480

EE2305 **3-1-0 (4)**

Microcontrollers and Digital Signal Processors

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the basic architectures of microcontrollers and Digital Signal Processors
CO-2	Apply assembly and Embedded C programming for embedded system applications
CO-3	Analyze timers, interrupts and interfacing techniques in embedded processors.
CO-4	Develop embedded and DSP-based motor control 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	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:

8051 Microcontroller - Intel 8051 architecture, memory organization, flags, stack, and special function registers, I/O, ports - connecting external memory, counters and timers, serial data I/O, Interrupts. Microcontroller instructions - addressing modes, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns. Microcontroller programming – Assembly Language Programming and programming with Embedded C, timer and counter programming, Interrupt programming.

PIC Microcontroller- Introduction - Architecture – Memory organization – Assembly Language programming and programming with Embedded C- simulation using MPLAB Integrated Development Environment (IDE) - Programming of I/O ports – Addressing modes Bank switching – Look-up Table and Table processing – Timers and its programming – Interrupt programming.

ARM Processor- processor Variants, - architecture-Different types of Instructions, ARM Instruction set, data processing instructions-Addressing Modes- -reset handling- Thumb instruction -memory organization, data operations and flow control- Instruction timing- Input/output mechanisms, isolated and memory mapped I/O; interrupts and real time operations, ARM interrupts- interrupts vectors, priorities and latency; supervisor modes, exceptions, traps, co-processors; cache memory and memory management- ARM tools- ARM Development Environment, Arm Procedure Call Standard (APCS), programming peripheral interface.

TMS320LF2407 Digital Signal Processor: Architecture, addressing modes, Instruction set, Assembly Language Programming, Fixed-Point Arithmetic, Interrupts, ADC, Event Managers, and simple motor control applications.

Learning Resources:

Text Books:

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, The 8051 Microcontroller and Embedded Systems, Pearson Education, 2006, 2nd Edition.
2. Muhammad Ali Mazidi, Rolin D. McKinlay and Danny Causey, PIC Microcontroller and Embedded Systems, Pearson Education, 2008, 1st Edition.
3. Andrew N. Sloss, Dominic Symes and Chris Wright, ARM System Developer's Guide, Morgan Kaufmann Publishers, 2008, 1st Edition.
4. Hamid A. Toliyat and Steven G. Campbell, DSP-Based Electromechanical Motion Control, CRC Press, 2004, 1st Edition.

Reference Books:

1. Kenneth J. Ayala and Dhananjay V. Gadre, The 8051 Microcontroller, Cengage Learning, 2009, 3rd Edition.
2. John H. Davies, MSP430 Microcontroller Basics, Newnes, 2008, 1st Edition.
3. Steve Furber, ARM System-on-Chip Architecture, Pearson Education, 2000, 2nd Edition.
4. Texas Instruments, TMS320LF240x DSP Controllers Reference Guide, Texas Instruments, 2002, Revised Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106105193
2. https://nptel.ac.in/courses/108102045

EE2307 **3-0-0 (3)**

Operation and Control of Power Systems

Pre-Requisites: EE2202

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 Modeling - Iterative methods - Gauss and Gauss Seidel Methods, Newton-Raphson Method- Fast Decoupled method - Merits and demerits of the Load flow methods - System data for load flow study.

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

Optimal System operation: Distribution of load between units within a plant, Transmission loss as a function of plant generation, Calculation of loss coefficients - Economic Load Dispatch with considering transmission losses.

Load Frequency Control: Introduction, load frequency problem-Megawatt frequency (or P-f control loop), MVAR- voltages (or Q-V) control loop-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-Inertia constant and 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): Introduction - Power system restructuring models-responsibilities and functions of independent system operator (ISO), deregulated (restructured) power system in India, Ancillary Services.

Text Books

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

Reference Books:

1. Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, Power System Generation, Operation and Control, John Wiley and Sons, 3rd Edition 2013.
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/

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	Analyse 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.

EE2381 **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

EE2302 **3-0-0 (3)**

FPGA Design

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze FPGA architectures and commercial FPGA platforms.
CO-2	Design combinational and sequential logic using Verilog HDL.
CO-3	Implement arithmetic circuits and waveform generators on FPGA hardware.
CO-4	Apply the FPGA design flow to real-time control and sensor-based 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	2	2	2	2	2	1	1	1	1	1	1	2	2
CO-2	3	3	3	3	3	1	1	2	1	2	1	3	3
CO-3	3	3	3	3	3	1	1	2	1	2	1	3	3
CO-4	3	3	3	3	3	1	1	2	1	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to FPGA Architectures

Overview of Field Programmable Gate Arrays (FPGAs). FPGA programming technologies and configuration methods. Configurable Logic Blocks (CLBs): structure and functionality. FPGA routing architectures and interconnection networks. Comparative overview of commercial FPGA families, including Xilinx (Artix, Kintex, Zynq, Virtex, Spartan) and Intel/Altera (Cyclone and Stratix) FPGA platforms.

Logic Design Using Verilog HDL

Introduction to Verilog HDL syntax and modeling styles. Behavioral modeling of combinational and sequential logic circuits. Synthesis concepts for combinational and sequential designs. Design and synthesis of datapath and controller architectures. Programmable logic and storage devices. Algorithms and architectures for digital processors. Architectures for arithmetic processors. Best coding practices and guidelines for FPGA-oriented Verilog design.

Verilog HDL Design of Arithmetic and Signal Generation Circuits

Verilog HDL implementation of basic arithmetic and logic circuits: adders, subtractors, multiplexers, demultiplexers, encoders, decoders, comparators, and registers. HDL-based design of waveform generators including sine, square, and triangular waveforms using lookup tables and digital techniques.

FPGA Design Flow and Prototyping

FPGA design flow: specification, RTL design, synthesis, implementation, timing analysis, and bitstream generation. FPGA prototyping techniques. Hardware validation and debugging methods using simulation tools, on-chip logic analyzers, and hardware test benches.

Case Studies and Applications

Case study on speed control of a DC motor using AC–DC and DC–DC power converters implemented with FPGA control logic. Sensor interfacing techniques using FPGA platforms. Introduction to FPGA-based object detection and real-time control applications.

Learning Resources:

Text Books:

1. Wolf, Wayne, “FPGA-based system design,” Pearson Education India, 2004.
2. Palnitkar, Samir, “Verilog HDL: a guide to digital design and synthesis,” Prentice Hall Professional, 2003.
3. C Unsalan, B Tar, “Digital System Design with FPGA: Implementation Using Verilog and VHDL,” Tata McGraw Hill, 2017, 1st Edition.

Other Suggested Readings:

1. Datasheets of Artix, Kintex, Zynq, Virtex, Spartan Boards
2. https://nptel.ac.in/courses/117108040

EE2304 **3-0-0 (3)**

Battery Management System

Pre-Requisites: None

Course Outcomes:

CO-1	Apply battery fundamentals to meet design requirements.
CO-2	Analyze the architecture and functionalities of Battery Management Systems.
CO-3	Analyze state estimation and cell balancing techniques.
CO-4	Evaluate thermal management and electrical protection strategies for EV batteries.

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

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, HPPC test

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, 2010.
4. Jiuchun Jiang and Caiping Zhang ; Fundamentals and Applications Of Lithium-Ion Batteries In Electric Drive Vehicles, 2015

Other Suggested Readings:

1. https://nptel.ac.in/courses/108106170

EE2306 **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

EE2308 **0-1-2 (2)**

EV & Charging Infrastructure Lab

Pre-Requisites: EE2303

Course Outcomes:

CO-1	Implement battery characterization, modelling, and state estimation techniques for lithium-ion batteries.
CO-2	Implement battery management functions, including cell balancing and protection mechanisms.
CO-3	Analyze the performance of EV power converters and bidirectional charging systems.
CO-4	Evaluate EV charging systems and battery thermal performance

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

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Study of Lithium-Ion Battery Charging and Discharging Characteristics and HPPC Test.
2. Implementation of equivalent circuit battery model (R_{int} / Thevenin model)
3. Analysis of Series–Parallel Configuration of Lithium-Ion Battery Packs
4. State of Charge (SoC) estimation using Coulomb counting method
5. SoC estimation using OCV method
6. Implementation of Kalman filter for SoC estimation
7. State of Health (SoH) estimation using capacity fade model
8. Implementation of Passive Cell Balancing in Lithium-Ion Battery Pack
9. Implementation of Active Cell Balancing Techniques
10. Implementation of Battery Protection Functions
    a. Overvoltage Protection (OVP)
    b. Undervoltage Protection (UVP)
    c. Overcurrent Protection (OCP)
    d. Short-Circuit Protection (SCP)
11. Performance Evaluation of DC–DC Buck Converter
12. Performance Evaluation of power factor correction DC–DC Boost converter
13. Implementation of Bidirectional DC–DC Converter for Electric Vehicle Applications
14. Hardware-in-the-Loop (HIL) Based EV Charger Implementation
15. Thermal Modelling and Analysis of Lithium-Ion Battery Pack using Simulink/ANSYS

Learning Resources:

Text Books:

1. Gregory L. Plett, Battery Management Systems, Vol. 1 & 2, Artech House, 2015.
2. Mohan Undeland Robin-Power Electronics-Converters, applications and design, John Wiley &Sons, 2016.

EE2310 **0-1-2 (2)**

Microcontrollers and DSP Application Lab

Pre-Requisites: EE2305

Course Outcomes:

CO-1	Implement basic applications using microcontrollers and Digital Signal Processors.
CO-2	Develop assembly and Embedded C programs for embedded system applications.
CO-3	Implement timers, interrupts and interfacing techniques in embedded processors.
CO-4	Develop embedded and DSP-based motor control 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	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

List of Experiments:

1. Interfacing of 8255 PPI and applications with 8086Microprocessor
2. Interfacing of 8254 and serial data transfer using 8251 USART with 8086Microprocessor.
3. Programming exercises on 8051, PIC Microcontroller and ARM Processor
4. Interface I/O devices with and handle external interrupts using ARM Processor
5. PIC Serial Communication using Serial Peripheral Interface (SPI) and Interface PIC 18F45K22 Microcontroller with an LCD using PIC microcontrollers simulator (IDE)
6. Verification of Sampling theorem withTMS320LF2407A
7. General programming exercises withTMS320LF2407A a) Arithmetic and logical operations b) Addressing modes c) Direct and indirect Data transfer d) Waveform generation e) Minimum and maximum values
8. Study of the GPIO Registers, ADC and interfacing with LEDs withTMS320LF2407A
9. PWM signal generation using Event Managers and dead time generation withTMS320LF2407A
10. Study of interrupts of TMS320LF2407 Processor withTMS320LF2407A

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.

EE2382 **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

EE2401 **3-0-0 (3)**

Motor Drives for EV

Pre-Requisites: EE1202

Course Outcomes:

CO-1	Analyze the concepts of EV motors
CO-2	Analyze the performance of electrical machines using reference frame theory
CO-3	Evaluate vector control scheme (field-oriented control (FOC)) for EV motors
CO-4	Identify the suitable power converter topologies for motor control

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	2	1	1	1	1	1	1	1	3	2
CO-2	2	3	3	2	1	1	1	1	1	1	1	3	2
CO-3	2	2	2	2	1	1	1	1	1	2	1	2	3
CO-4	2	3	3	2	3	1	1	1	1	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction:
Classification of EV motors, and Comparison of Electric motors for EV applications, Recent EV motors.

DC Motor Drives:
DC Machine modeling, DC Motor Control, controller design criteria of DC Drives.

Transformations:
Types of transformation, condition for power invariance and magnitude invariance, Clarke and Park's Transformations, Variables observed from various frames, Simulation studies.

Induction Motor Drives:
Basics of induction motor, Induction Machine modeling, open-loop v/f control, basics of DC-AC power converters, basic pulse width modulation techniques, vector control of IM drives: direct and indirect field-oriented control (FOC).

Brushless DC Motor Drives:
BLDC machines, Modeling, commutation process and control schemes.

Permanent Magnet Synchronous Motor (PMSM) Drives:
Types of PMSM (SPMSM and IPMSM), PMSM modeling, field-oriented control (FOC) for SPMSM and IPMSM drive, MTPA and MTPV schemes for IPMSM drives.

Learning Resources:

Text Books:

1. Ramu Krishnan, Electric motor drives: modeling, analysis, and control, Pearson Education India,2015, 1st Edition.
2. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery and Drive systems, Wiley-IEEE Press, August 2013, 3rd Edition.
3. De Doncker, Rik W., Pulle, Duco W.J., Veltman, Andre, "Advanced Electrical Drives, Analysis, Modelling, Control", 2nd Edition, 2020, Springer, ISBN 978-3-030-48977-9.

Reference Books:

1. K. T. Chau, “Electric Vehicle Machines and Drives: Design, Analysis and Application”, John Wiley & Sons, Singapore Pt. Ltd. 2015, ISBN:9781118752524.
2. John G. Hayes, G. Abas Goodarzi, “Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and 15 Go to Index Fuel Cell Vehicles”, John Wiley & Sons Ltd, 2018, ISBN:9781119063643

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee33
2. http://digimat.in/nptel/courses/video/108106023/L28.html

EE2403 **0-1-2 (2)**

Power Converters & Drives Lab for E-Mobility

Pre-Requisites: EE2303 & EE2401

Course Outcomes:

CO-1	Verify the operation of rectifiers, DC-DC converters and inverter circuits.
CO-2	Evaluate various performance indices of power converters
CO-3	Design the control and power circuit for electric motors.
CO-4	Compare unipolar and bipolar PWM techniques for single-phase 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	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

List of Experiments:

1. Study and design of magnetic components for DC-DC converters
2. Performance analysis of non-isolated DC-DC converters.
3. Performance analysis of a Forward DC-DC converter.
4. Performance analysis of a Fly back DC-DC converter.
5. Study of uni-polar and bi-polar PWM based single-phase inverter.
6. Speed control of 3Φ slip-ring induction motor by rotor resistance control method.
7. Study of speed control of 3 Φ inverter fed induction motor based on V/f (slip speed) control method.
8. Study the speed control of 3Φ induction motor based on field-oriented control (FOC) method.
9. Study the speed control of 3Φ PMSM based on field-oriented control (FOC) method
10. Speed control of 3Φ BLDC motor
11. FEA of BLDC and PMSM motors
12. Range evaluation for PMSM motor using HIL testing method

Learning Resources:

Text Books:

1. M.H. Rashid, Power Electronics-Circuits, Devices and Applications, PHI, 2009.
2. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2016.
3. Mohan Undeland Robin-Power Electronics-Converters, applications and design, John Wiley &Sons, 2016.

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

Power Systems Lab

Pre-Requisites: EE2307

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

EE2489 **0-0-0 (2)**

Seminar and Technical Writing

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

EE2491 **0-0-0 (2)**

Short Term Industrial / EPICS / Research Experience

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

EE2495 **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

EE2498 **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

EE2322 **3-0-0 (3)**

Advanced Power Electronic Converters for E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Evaluate the performance of classical and advanced high-gain DC–DC converter topologies.
CO-2	Analyze bidirectional DC–DC converter topologies and resonant converter configurations.
CO-3	Design onboard EV charging systems with PFC.
CO-4	Apply various PWM schemes to single-phase and three-phase 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	3	3	3	2	1	1	1	1	3	3
CO-2	3	3	3	3	3	3	2	1	1	1	1	3	3
CO-3	3	3	3	3	3	3	2	1	1	1	1	3	3
CO-4	3	3	3	3	3	3	2	1	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

High gain DC-DC converters: Refresh on classical DC-DC topologies (Qualitative), coupled inductor DC-DC converters, switched capacitor converters, switched inductor converters, interleaved converters. Design of inductors, capacitors and devices selection.

Bidirectional DC-DC Converters (BDCs): Introduction, Concept of Bidirectional Power flow converter, non-isolated- buck/boost and buck-boost based BDCs. Isolated-Dual Active Bridge (DAB) converter.

Resonant Converters: Introduction, Basic resonant circuit concepts, Classification - Load resonant converters, resonant switch converters, zero voltage and zero current switching converters, Phase modulated resonant converters.

Onboard Charger (OBC) systems: Classical rectifier with power factor correction (PFC), PWM rectifiers/Bidirectional AC-DC converters (1-phase & 3-Phase) with V2G & G2V modes of operation, interleaved and Totem-pole converters. Converters for wireless power transfer (WPT). On-board vs. Off-board charger architectures (Qualitative).

Inverters: Single-phase and three-phase inverters - PWM techniques: single-pulse, multi-pulse and sinusoidal PWM techniques - selective harmonic elimination, space vector modulation, current source inverter, multi-level inverters (MLIs) - Carrier and Vector based multi-level modulation schemes.

Learning Resources:

Text Books:

1. M.H. Rashid **:** Power Electronics Handbook, Butterworth-Heinemann, 2017, 4th edition.
2. Umanand, L.: Power Electronics: Essentials and Applications, John Wiley India, 2009, 1st Edition.
3. N Mohan, T.M. Undeland, WP.Robbins**:** Power Electronics: Converters, Applications**,** John Wiley & Sons, 2003, 3rd Edition.
4. Bin Wu, Mehdi Narimani: High Power Converters and AC Drives, Wiley-IEEE Press, 2017, 2nd Edition.

Reference Books:

1. R.W. Erickson and Dragan Maksimonic, Fundamentals of Power Electronics, Springer, 2020, 3rd Edition.
2. Marian K. Kazimierczuk "Pulse-width Modulated DC-DC Power Converters", John Wiley & Sons Inc, 2nd Edition 2025.
3. Abraham I. Pressman, Keith Billings & Taylor Morey: Switching Power Supply Design, McGraw Hill International, 2009, 3rd Edition.
4. Jayant Baliga B: Fundamentals of Power Semiconductor Devices, Springer, 2008,1st Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108105066
2. https://nptel.ac.in/courses/108102145
3. http://digimat.in/nptel/courses/video/108101038/L36.html
4. http://digimat.in/nptel/courses/video/108101126/L92.html

EE2324 **3-0-0 (3)**

Safety and Testing for Electric Vehicles

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the fundamentals of EV testing, standards and safety
CO-2	Evaluate EMI/EMC performance of Electric Vehicles using specialized equipment
CO-3	Analyze electrical safety and battery durability through tests
CO-4	Analyze EV Supply Equipment charging and grid compliance

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

Syllabus:

Introduction to EV testing and standards: Scope of EV testing: safety, performance, EMI/EMC, battery, powertrain, charging, and real-world validation, Role of type-approval, homologation, and international standards (UN/ECE R10, ISO, IEC, SAE, GB, ARAI, etc.). Need for automated, high-voltage, high-power test systems in EV industries, Drive cycles, vehicle testbed for 2W/3W, range test, Motor and drive testing

EV safety Electrical and functional standards: ELV / EV safety standards: insulation resistance, dielectric strength, isolation monitoring, protection against indirect contact, High-voltage DC and EVSE standards (e.g., UL 2594, IEC 61851, GB/T, CCS/CHADEMO interface testing), Performance and durability tests: battery cycle life, thermal abuse, vibration (SAE J2380), and mechanical shock

EMI and EMC standard for EVs: EMC fundamentals: EMI, conducted/radiated emissions, immunity, coupling paths, Key EV EMC standards: UN/ECE R10, ISO 11452- series (radiated immunity), ISO 7637-2 (transients), IEC 61000- series (harmonics, flicker)

EMI/EMC test equipment and setup: EMI/EMC measurement chain: antennas, LISNs, current probes, EMI receivers, spectrum analyzers, oscilloscopes, LISN, coupling networks, Anechoic / semi-anechoic chambers, shielded rooms, ground planes, and test furniture, Anechoic / semi-anechoic chambers, shielded rooms, ground planes, and test furniture, Immunity test equipment: RF generators, CDN, surge generators, coupled energy sources; ripple-immunity test systems (e.g., high-voltage ripple-test systems up to 100 V at 200 kHz)

Advanced EV power and battery testbed system: High-power EV test equipment: bidirectional DC power supplies, grid simulators, battery cyclers, regenerative loads, Battery-level tests: performance, cycling, aging, impedance (EIS), HPPC, and UN/DOT 38.3 compliance, Motor-in-the-loop (MIL) / powertrain test benches, dynamometers, and real-world drive-cycle emulation

EVSE, charging and system level equipment: EVSE and DC-fast-charger test systems: ripple-current immunity, conducted/radiated EMC, fault-ride-through, and grid-interconnection standards (IEEE 1547, SAE J2894)**,** Safety and compliance test equipment for EVSE: UL 2594-type tests, insulation, leakage current, ground-fault, and over/under-temperature checks

Learning Resources:

Text Books:

1. Mehrdad Ehsani et al.: Modern Electric, Hybrid Electric and Fuel cell vehicles : Fundamentals, Theory and Design, CRC Press, 3rd edition, 2022.
2. P. N. Rao: Manufacturing Processes, Tata McGraw Hill Publications, 3rd edition, 2009.

Online Resources:

1. Automotive Electromagnetic Compatibility (EMC) test standards – LEARNEMC / ISO/IEC-based notes.
2. EVSE Testing & Measurements – Tektronix EVSE test solutions.
3. EMC Test Equipment Guides – Rohde & Schwarz / R&S based EMC notes.

EE2326 **3-0-0 (3)**

Thermal Management in EVs

Pre-Requisites: None

Course Outcomes:

CO-1	Apply heat transfer principles for thermal load estimation in EV batteries, motors, and power electronics.
CO-2	Analyze the impact of thermal management on EV performance, safety, efficiency, and driving range.
CO-3	Evaluate battery thermal management strategies based on cooling effectiveness, temperature uniformity, and thermal runaway mitigation.
CO-4	Select suitable thermal management strategies for EV motors, power electronics, and HVAC systems based on safety and sustainability requirements.

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

Syllabus:

Fundamentals for heat transfer for EVs: Conduction, convection, and radiation basics in EV systems, Heat exchangers, fins, and heat-sink concepts for EV components, Estimation of cooling/heating loads for battery, motor, and electronics.

Thermal management in EV: Role of temperature in EVs: battery, motor, power electronics, cabin comfort, and range, Major heat sources: battery pack, power electronics (inverter, DC–DC), motor, cabin HVAC, Impact of temperature on performance, safety, lifetime, and efficiency

Battery Thermal management: Heat generation mechanisms in Li-ion cells and packs, Passive (air, phase-change materials) and active (liquid cooling, refrigerant-based) BTMS, Temperature uniformity, thermal runaway, and emergency cooling strategies

Thermal management for Motor and Power electronics: Losses and heat sources in electric motors and power electronics, Air-cooled and liquid-cooled motor/heat-sink designs (minichannel, immersed cooling), Active methods: jet impingement, heat pipes, thermoelectric (Peltier) cooling, and synthetic jets.

Heating Ventilation and Air conditioning system: Heat pump vs resistive HVAC; energy penalty on range, integrated thermal management: battery cool, motor cooling, and cabin HVAC sharing one coolant loop, Energy efficiency and COP-based analysis for EV thermal systems

Safety standard and sustainability: Safety aspects: thermal runaway propagation, fire-retardant materials, emergency cooling, Relevant standards and regulatory guidelines for EV thermal systems, Sustainability and lifecycle impact of cooling fluids, materials, and design choices

Learning Resources:

Text Books:

1. Hafiz Muhammad Ali, “Thermal Management for Batteries: From Basic Design to Advanced Simulation and Management Methods,” Academic Press Inc, 2024, 1st Edition.
2. Ashwani Kumar, Mukesh Kumar Awasthi, “Thermal Battery Management System for Hybrid and Electric Vehicles,” Wiley, 2025.

3. I. Dincer, H. S. Hamut, and N. Javani, Thermal Management of Electric Vehicle Battery Systems, Wiley, 2017.

Reference Books:

1. Fethi Aloui, Edwin Geo Varuvel, Ankit Sonthalia, “Handbook of Thermal Management Systems e-Mobility and Other Energy Applications,” 2023, 1st Edition.
2. D Rahn and Chao-Yang Wang, “Battery Systems Engineering,” Wiley, 2013
3. Y. Shabany, “Heat Transfer: Thermal Management of Electronics” CRC press, 2009.

EE2328 **3-0-0 (3)**

Switchgear and Protection

Pre-Requisites: None

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, SF6 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	2	2	2	3	2	1	2	1	2	1	3	2
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	3	3
CO-4	3	3	2	2	2	2	1	2	1	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Switchgear: Introduction-Necessity- essential features of switchgear- need of current limiting reactors and their arrangements

Fuses: Desirable characteristics of a fuse element- factors affecting fuse current- important terms- current rating- fusing current- fusing factor- prospective current- cut off current- pre-arcing time- arcing time- total operational time- breaking capacity-Types of fuses-high voltage fuses -low voltage fuses--HRC-construction-working- applications

Circuit breakers: Arc Phenomenon-Arc formation process-methods of arc extinction -high resistance - low resistance-important terms-Arc voltage-recovery voltage-re-striking voltage-RRRV. Specifications of circuit breaker-Rated current- Rated voltage-braking capacity-making capacity- short time rating-circuit breaker classifications-construction- operation-advantages -Oil circuit breaker-air blast-Vacuum-SF6. Comparison between fuse and circuit breaker

Isolators: Types- construction-vertical break-horizontal break - pantograph type

Protective relays: Typical relay circuit- fundamental requirements of protective relays- basic terminology-relay time- pick up current- reset current- current setting- plug setting multiplier- time setting multiplier-Classification of relays- based on applications- based on time of operation- time current characteristics

Electromagnetic relays: Attraction types relays-construction - operation- attracted armature type-solenoid type-induction type relays-construction- working- over current (non-directional and directional)

Distance and differential protection: Principle of operation- distance relay- differential relay.

Static relay: (block diagram only), Comparison between static and electromagnetic relays. Types of protection- basic concepts with diagram -primary – backup

Faults in electrical machines: Important faults in alternators, transformers, electric motors

Protection of Alternators: Differential protection- Merz price scheme- earth fault

Protection of Transformers: Buchholz relay- construction- operation- earth fault (leakage) protection-combined leakage and overload protection-Merz price circulating current scheme.

Protection of motors: Short circuit protection-overload protection-single phase preventer

Protection of Busbars: Schemes of protection- differential protection- fault bus protection

Protection of transmission lines: Requirements of line protection system- methods of protection-schematic arrangement and principle of - time graded over current protection (for radial, parallel and ring main feeders)- differential pilot wire protection-Merz price voltage balance system-distance protection

Protection against over voltages: List causes of over voltage-voltage surge (definition only)

Lightning- definition-mechanism of lightning discharge- lightning stroke- types-harmful effects of lightning-Protection against lightning- devices used- overhead ground wires- Lightning arrestors-horn gap arresters (basic diagram and working only)

Microprocessor based over current and Distance relays: Block diagram-working

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. 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/108101039

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

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 coach 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/

EE2330 **3-0-0 (3)**

Vehicle Frames and Structures for E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Compare EV and ICE architectures and calculate the forces acting on the vehicle frame.
CO-2	Analyze vehicle dynamics and load cases (static/dynamic) to determine the forces acting on an EV frame.
CO-3	Select suitable materials and manufacturing methods based on weight, cost, and eco-friendliness.
CO-4	Design safe frames to protect the battery pack during crashes and manage heat.

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

Syllabus:

Introduction to E- mobility and Vehicle frame: Role of vehicle frame/chassis in EVs vs ICE vehicles; safety, weight, and packaging constraint, Overview of different EV architectures: 2-w, 3-w, 4-w; skateboard platforms and unibody concepts

Vehicle dynamics and frame load: Basic vehicle dynamics: longitudinal, lateral, and vertical forces; acceleration, braking, cornering, Static and dynamic load cases on frame: kerb weight, GVW, crash, NVH, and torsion, Safety and crash-worthiness requirements for EV frames (front/side/rear impact, rollover)

Materials for EV frame: Classification of materials - low-carbon steel, HSLA, AHSS, aluminium alloys, magnesium, composites, Role of specific materials, High-strength steels for safety cages, Aluminium for weight reduction in extruded frames and battery trays, Material selection criteria: strength-to-weight ratio, cost, manufacturability, recyclability, battery-pack integration.

Frame design and manufacturing: Frame types: ladder frame, space frame, monocoque/unibody; EV-specific skateboard frame.

Design process: Static stiffness and modal analysis goals, Method of joints/sections; beam-column analogy basics, Manufacturing routes: stamping, hydroforming, extrusion, welding, adhesive bonding; energy and carbon footprint aspect

Battery pack integration and structural role of frame: Framing the battery pack: bottom-mounted “floor pan” vs bolt-down designs, Crash-safety of battery: intrusion protection, crash-box design, load paths, Thermal management interfaces: coolant channels, isolation from frame, fire-retardant material

Light weighting strategies, Sustainability and standards: Light weighting strategies: topology optimization, multi-material frames, hybrid joints, Lifecycle considerations: CO_2 footprint of frame materials, repairability, recyclability, Relevant Indian and international standards for EV structures (GSR notifications, AIS, Euro NCAP, etc.

Learning Resources:

Text Books:

1. John G. Hayes and G. Abas Goodarzi, Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, Wiley, 2018, 1st Edition.
2. Mehrdad Ehsani, Yimin Gao, Sebastian E. Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2023, 3rd Edition.
3. C. C. Chan and K. T. Chau, Modern Electric Vehicle Technology, Oxford University Press, 2001, 1st Edition.

Reference Books:

1. K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley-IEEE Press, 2015, 1st Edition.
2. Pankaj K. Mallick (Ed.), Materials, Design and Manufacturing for Lightweight Vehicles, Woodhead Publishing, 2020, 1st Edition.
3. Kaushik Kumar, Bathini Sridhar Babu and J. Paulo Davim, Lightweight Materials: Processing and Characterization, John Wiley & Sons, 2021, 1st Edition.
4. James Njuguna, Lightweight Composite Structures in Transport, Woodhead Publishing, 2016, 1st Edition.

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/

EE2421 **3-0-0 (3)**

Renewable Energy Sources

Pre-Requisites: None

Course Outcomes:

CO-1	Assess the environmental impacts and sustainability of renewable energy technologies.
CO-2	Analyze solar radiation characteristics and solar energy conversion technologies.
CO-3	Evaluate wind, biomass, and tidal energy conversion systems based on their operating characteristics.
CO-4	Analyze the principles of ocean thermal energy conversion and hydrogen energy.

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: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale.

Solar Energy: Fundamentals, Solar Radiation, Estimation of solar radiation on horizontal and inclined surfaces, Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector, solar distillation, solar irradiation forecasting

Solar electric power generation: Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system, MPPT techniques.

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind, major problems associated with wind power, Basic components of wind energy conversion system (WECS), Classification of WECS- Horizontal axis- single, double and muliblade system, Vertical axis- Savonius and darrieus types**.**

Biomass Energy: Introduction, Photosynthesis Process, Biofuels, Biomass Resources, Biomass conversion technologies-fixed dome, Urban waste to energy conversion, Biomass gasification

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations**.**

Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.

Fuel Cells: Introduction, Classification, Operating principles, characteristics, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only)

Learning Resources:

Text Books:

1. G. D. Rai, Nonconventional Energy sources, Khanna Publication, Sixth Edition, 2017.
2. S. Rao and B. B. Parulekar, Energy Technology, Khanna Publication, 2015.
3. Subhas P. Sukhatme, Solar energy, Tata Mc Graw-Hill, 2nd edition,1996.

Reference Books:

1. Principles of Energy conversion, A. W. Culp Jr.,, McGraw Hill, 1996
2. Non-Convention EnergyResources, Shobh Nath Singh, Pearson, 2018

Other Suggested Readings:

1. https://nptel.ac.in/courses/121106014
2. https://nptel.ac.in/courses/103103206

EE2423 **3-0-0 (3)**

EV Embedded Systems & Communication

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the architecture of EV embedded systems and major controllers.
CO-2	Evaluate embedded hardware and software for sensing, motor control, and charging for EVs.
CO-3	Analyze EV in-vehicle communication networks and vehicle connectivity technologies.
CO-4	Evaluate functional safety and cybersecurity mechanisms in EVs.

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	1	2	1	1	1	1	1	3	2
CO-2	3	2	3	3	1	1	2	1	1	1	1	3	2
CO-3	3	3	2	3	1	2	1	2	1	2	1	3	2
CO-4	3	3	1	2	3	1	2	1	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to EV Embedded Systems: Overview of electric vehicle types: Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), and Fuel Cell Electric Vehicles (FCEV). Basic EV electronic architecture and the role of major controllers such as Battery Management System (BMS), Vehicle Control Unit (VCU), Motor Controller, and On-Board Charger (OBC). Introduction to automotive microcontrollers and real-time operating systems (RTOS). Basics of AUTOSAR architecture, firmware development flow, and automotive safety standards

Automotive Embedded Hardware and Software: Microcontroller fundamentals including timers, interrupts, power modes, and peripheral interfacing. Sensors and actuators used in EVs for voltage, current, temperature, and motor control applications. Battery monitoring and state estimation methods. Embedded control of motors and charging systems. AC and DC charging concepts, charging communication protocols, and plug-and-charge systems for EV charging infrastructure.

In-Vehicle Communication Networks: Introduction to Controller Area Network (CAN) and CAN-FD communication. CAN message structure, arbitration, and error handling. Diagnostic communication and fault monitoring using OBD-II and UDS protocols. Overview of LIN, FlexRay, and Automotive Ethernet networks. Comparison of communication protocols used in modern electric vehicles and advanced driver assistance systems (ADAS).

Telematics and Vehicle Connectivity: Low-voltage electrical systems and DC-DC converters in EVs. Vehicle sensing using encoders and IMUs. Introduction to telematics systems, GPS/GNSS, and cloud connectivity. Over-the-air (OTA) software updates and wireless communication protocols such as BLE and MQTT. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication concepts and standards.

Safety and Cybersecurity in Electric Vehicles: Hazard Analysis and Risk Assessment (HARA) and ASIL assignment; functional and technical safety requirements with ASIL decomposition; safety mechanisms including MISRA C, watchdog timers, lockstep cores, and E2E protection; SOTIF for ADAS performance limitations; attack surface analysis across CAN, OBD-II, TCU, and V2X; TARA methodology per ISO/SAE 21434; hardware cybersecurity controls including secure boot, HSM, and ARM Trust Zone and emerging trends in Software-Defined Vehicles and AUTOSAR Adaptive Platform.

Learning Resources:

Text Books:

1. Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House, 2010.
2. Robert Bosch GmbH, Automotive Handbook, 10th Edition, Wiley, 2022.
3. Wolfhard Lawrenz (Ed.), CAN System Engineering: From Theory to Practical Applications, Springer, 2013.

Reference Books:

1. Ali Emadi (Ed.), Advanced Electric Drive Vehicles, CRC Press, 2015.
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition, CRC Press, 2021.
3. SAE Standards: J1939, J1772, J2735; ISO Standards: 11898-1/2 (CAN), 15118-2, 26262, 14229 (UDS), 17987 (LIN); ISO/SAE 21434; IEC 61851-1; UNECE WP.29 Regulations 155 and 156.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=SRVswRH5Q7E
2. https://nptel.ac.in/courses/106106129
3. https://nptel.ac.in/courses/108106170

EE2425 **3-0-0 (3)**

Autonomous driving in E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the evolution, architecture, market trends, and challenges of autonomous electric vehicles in Indian road conditions.
CO-2	Analyze sensor technologies, sensor fusion, and perception algorithms used in autonomous electric vehicles.
CO-3	Apply autonomous driving algorithms, control strategies, and AI/ML techniques in electric vehicle systems.
CO-4	Evaluate connected vehicle technologies, simulation tools, and testing methods for ADAS and autonomous driving 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	2	2	1	1	–	–	–	–	2	3	2
CO-2	2	3	2	3	1	2	1	–	–	–	1	1	2
CO-3	3	2	3	2	1	2	1	1	1	2	1	3	2
CO-4	2	2	1	3	3	1	–	–	–	–	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Autonomous Vehicles and Electric Mobility: Overview of autonomous electric vehicle (AEV) technology; Evolution and current state of autonomous driving; Impact of AEVs on Mobility, Current market perspective of AEVs, Road conditions and challenges for AEVs, Implications of road conditions for AEVs, Technological requirements, Detection system and its analysis, Infrastructure requirements for AEVs, Emerging trends and future directions in autonomous vehicle technology and electric mobility,

Autonomous Vehicle Sensors and Perception Systems: Sensors used in autonomous vehicles (LiDAR, radar, cameras, ultrasonic sensors, etc.), Principles of operation and applications of each sensor type, Sensor fusion techniques for combining data from multiple sensors, Perception algorithms for object detection, classification, and tracking in electric AEVs; Challenges and solutions in sensor integration for electric vehicles.

Autonomous Driving Algorithms and Control Systems for Electric Vehicles: Integration of autonomous technology with electric vehicle architecture; SAE levels of AEV Software Stack Architecture, Overview of autonomous driving algorithms, Control systems for AEVs- adaptive cruise control, lane-keeping, and automated parking; Integration of machine learning and artificial intelligence in autonomous electric vehicle control; Safety considerations (blind spot detection, forward collision warning, Automatic emergency braking), and fail-safe mechanisms.

Connected Vehicle Fundamentals: Overview of wireless networks for connected vehicles, Standards for autonomous vehicle applications, Transmission and receiver systems in automotive communication, Radio transmission principles, Concepts of wireless communication for automotive applications, Wireless networking and its applications in vehicle autonomy, Basics of computer networking and the Internet of Things (IoT), Wireless networking fundamentals, Evolution and overview of 2G to 5G networks for automotive applications.

Simulation of Autonomous Vehicle Systems: Introduction to simulation for ADAS / Autonomous Driving (AD), Common tools and platforms for simulation, Simulation components: sensors, maps, and traffic scenarios, Introduction to ADAS software testing process, Unit testing, system testing, and integration testing.

Learning Resources:

Text Books:

1. Husain, I., "Electric and hybrid vehicles: design fundamentals," CRC Press, 2021.
2. Gillespie, T., "Fundamentals of vehicle dynamics," SAE International, 2021.
3. Rajamani, R., "Vehicle dynamics and control," Springer Science & Business Media, 2011.
4. Sciarretta, A., & Vahidi, A., "Energy-efficient driving of road vehicles," Springer International Publishing, 2020.

Reference Books:

1. M. Maurer, J. C. Gerdes, B. Lenz, and H. Winner, Autonomous Driving: Technical Legal and Social Aspects, Berlin, Germany: Springer, 2016.
2. S. Thrun, W. Burgard, and D. Fox, "Probabilistic Robotics," Cambridge, MA, USA: MIT Press, 2005.
3. J. F. Kurose and K. W. Ross, "Computer Networking: A Top-Down Approach," Boston, MA, USA: Pearson, 2017, 7th Edition.
4. Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A., "Autonomous vehicle technology: A guide for policymakers," Rand Corporation, 2014.
5. Qu, Z., Cooperative control of dynamical systems: applications to autonomous vehicles. Springer Science & Business Media, 2009.

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

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

EE2422 **3-0-0 (3)**

Manufacturing Technologies for E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze EV manufacturing processes and production systems.
CO-2	Select appropriate materials and forming processes for EV frames and body structures
CO-3	Analyze the step-by-step assembly of battery packs, including cell coating, bus-bar joining, and leak testing
CO-4	Apply specialized manufacturing techniques for EV motors, power electronics, and high-voltage wiring harnesses

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

Syllabus:

Introduction to E-mobility manufacturing: Evolution of EV manufacturing: ICE vs EV production lines, Scope of e-mobility manufacturing: battery packs, motors, power electronics, frames, and electronics, Evolution of EV manufacturing: ICE vs EV production lines.

Materials and processes for EV technology: Materials: AHSS, HSLA, aluminium, magnesium, composites for frames, chassis, and body-in-white, Forming, stamping, hydroforming, and extrusion of EV frame

Battery pack manufacturing: Cell manufacturing basics (cathode/anode coating, drying, calendaring, cell assembly), Battery pack assembly: cell stacking, bus-bar joining, thermal-pad insertion, housing/enclosure assembly, Leak testing, EMI, thermal-runaway protection, and automated pack-assembly lines

Motor and power electronics manufacturing: Stator and rotor manufacturing: lamination stacking, winding (hairpin, distributed), slot insulation, and over molding, Soft magnetic composites (SMC) for rotors and cores, Motor assembly: housing, bearings, shafts, and cooling-integrated rotors, Manufacturing of power electronics: PCB assembly, SMD, press-fit, conformal coating, heat-sink mounting, and power-module packaging

Processes of EV electronics and sensors: Through-hole vs SMD assembly, reflow and wave soldering, Printed circuit boards, connectors, cable harnesses, and harness routing for EVs, Sensor integration (temperature, pressure, current, position) and protection from vibration, EMI, and moisture

Learning Resources:

Text Books:

1. Mallick, Pankaj K., ed. Materials: Design and manufacturing for lightweight vehicles, Woodhead publishing, 2020.
2. Hafiz Muhammad Ali: Thermal Management for Batteries, From Basic Design to Advanced Simulation and Management Methods, Academic Press Inc, 1st edition, 2024.
3. Fethi Aloui, Edwin Geo Varuvel, Ankit Sonthalia: Handbook of Thermal Management Systems e-Mobility and Other Energy Applications, Elsevier, 1st edition, 2023.

Reference Books:

1. Kaushik Kumar, Bathini Sridhar Babu and J. Paulo Davim, Lightweight materials: processing and characterization. John Wiley & Sons, 2021.
2. P. N. Rao: Manufacturing Technology: Foundry, Forming and Welding, Tata McGraw-Hill, 3rd edition, 2009.

EE2424 **3-0-0 (3)**

Applications of AI for E-Mobility

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the fundamental concepts of Artificial Intelligence and Machine Learning
CO-2	Apply AI techniques for battery modelling, state estimation, and BMS optimization.
CO-3	Analyze electric powertrain performance using AI techniques.
CO-4	Design AI-driven solutions for smart charging, grid integration (V2G), and predictive maintenance.

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	1	-
CO-2	3	3	2	2	3	2	-	-	-	-	2	3	2
CO-3	3	2	3	2	3	2	-	-	-	-	2	3	2
CO-4	3	3	3	3	3	3	-	1	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of Artificial Intelligence: Introduction to AI and Machine Learning, Supervised, Unsupervised and Reinforcement Learning, Artificial Neural Networks and Deep Learning basics, Feature engineering and model evaluation, AI frameworks and tools, Overview of the AI workflow: Data acquisition, cleaning, exploration, model building, and deployment. Applications of AI in energy systems and transportation.

AI for Battery Management Systems (BMS): Overview of Lithium-ion battery modelling, AI-based State of Charge (SoC) / State of Health (SoH) estimation, Neural networks for battery parameter estimation, Machine learning for thermal management of batteries, Case study: AI-driven BMS in electric vehicles.

AI in Electric Powertrain: Architecture of electric vehicles, Electric motor control and power electronics, AI for energy management strategies, Reinforcement learning for torque and speed control, AI-based vehicle energy optimization, Digital twin for electric powertrain diagnostics.

AI for EV Charging Infrastructure: EV charging architectures and standards, Smart charging and load management, AI for demand forecasting in charging stations, Reinforcement learning for charging scheduling, Vehicle-to-grid (V2G) optimization using AI, AI-enabled grid integration of EVs.

AI for Predictive Maintenance: Predictive maintenance concepts, Fault detection using machine learning, AI for battery degradation prediction, AI for motor and inverter fault diagnosis and condition monitoring.

Learning Resources:

Text Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville: Deep Learning, The MIT Press 2016.
2. Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, AI Prentice Hall, 3rd Edition, 2010.
3. James Larminie, John Lowry: Electric Vehicle Technology Explained, Wiley, 2nd Edition, 2012.
4. R. Xiong & W. Shen: Advanced Battery Management Technologies for Electric Vehicles, Wiley, 2019.

References:

1. M. A. Hannan, Md. Murshadul Hoque, Aini Hussain, Yushaizad Yusof and Pin Jern Ker, A Review of Lithium-Ion Battery State of Charge Estimation and Management System in Electric Vehicle Applications: Challenges and Recommendations, Renewable and Sustainable Energy Reviews, Elsevier, 2017.
2. Azadeh Kermansaravi, Mohammad Reza Shaarbaf and Amir Mosavi, AI-Based Energy Management Strategies for Electric Vehicles: Challenges and Future Directions, Energy Reports, Elsevier, 2024.
3. Xuning Feng, Yuchen Lu et al., Deep Learning to Estimate Lithium-Ion Battery State of Health Without Additional Degradation Experiments, Nature Communications, Springer Nature, 2023.
4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, 2019, 2nd Edition.

EE2426 **3-0-0 (3)**

Electric Vehicle Charging Infrastructure

Pre-Requisites: None

Course Outcomes:

CO-1	Compare different EV architectures and explain battery charging characteristics.
CO-2	Design smart charging infrastructure for Electric Vehicles.
CO-3	Analyze grid impacts due to EV penetration
CO-4	Apply smart charging and V2G strategies, techno-economic and regulations

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:

Electric Vehicles and Charging Technologies: Evolution of EVs and hybrid vehicles, Types: BEV, HEV, PHEV, FCEV, EV, Powertrain architecture, Battery technologies (Li-ion, Solid-state), Charging characteristics of batteries, charging levels, conductive vs inductive charging, Charging standards, On-board and off-board chargers, Battery packaging

Impact of EVs on Power Grid: Load demand characteristics of EVs, Charging Effects on: Voltage profile, Frequency stability, Transformer loading, Harmonics and power quality, Case studies.

EV Charging Infrastructure: Types of charging stations: Home, public, fast-charging stations, Site selection and sizing, distribution system constraints, GIS-based planning approaches, Smart Charging & Demand Response: Time-of-use pricing, Load shifting and peak shaving, Demand response techniques, Communication protocols: OCPP, IEC 61850, Role of IoT, and smart meters, Testing of EV chargers.

Vehicle-to-Grid (V2G) Technology: Concept of V2G, V2H, V2B, Bidirectional power flow, Aggregators and controllers, Frequency regulation and ancillary services, Challenges: battery degradation, control complexity, charging connectors.

Renewable Integration with EV Charging: Solar-powered EV charging stations, Energy storage integration, Microgrid-based EV charging, Hybrid systems (PV + Battery + Grid).

Policies, Standards & Economics: EV policies in India, Tariff structures for EV charging, Regulatory bodies, Business models: Charging-as-a-service, Battery swapping, Economic analysis and cost-benefit, charging standards.

Learning Resources:

Text Books:

1. C. C. Chan, K. T. Chau, Modern Electric Vehicle Technology, Oxford University Press, 2001.
2. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.

Reference Books:

1. A. W. Culp Jr.,, Principles of Energy conversion, Tata McGraw Hill, 1996.
2. Shobh Nath Singh, Non-Convention Energy Resources, Pearson, 2018.

Other Suggested Readings:

1. https://www.iea.org/reports/global-ev-outlook
2. https://powermin.gov.in

EE2428 **3-0-0 (3)**

Machine Design for E-Mobility

Pre-Requisites: None

Course Outcomes (COs):

CO1	Analyze fundamental electrical and magnetic design concepts of rotating electrical machines.
CO2	Design induction motors for electric vehicle applications
CO3	Design PMSM/IPMSM drives for high-performance electric vehicles.
CO4	Select suitable rotating machines for electric vehicle 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	1	1	1	1	1	1	1	3	2
CO-2	2	3	3	3	1	1	1	1	1	1	1	2	2
CO-3	2	2	3	3	1	1	1	1	1	2	2	2	3
CO-4	3	3	3	3	2	1	1	1	1	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to E-Mobility Traction Motors
EV Drive Requirements: Acceleration, torque-speed characteristics, efficiency maps, and high-speed operation, Machine Types for EV: Comparative analysis of PM Motors (PMSM, SPMSM, IPMSM), Induction Motors (IM), Design Constraints: Weight reduction, volume constraints, and thermal management, Motor Standards: Regulatory requirements and standard operating procedures.

Magnetic and Electrical Design Fundamentals
Sizing Equations: Derivation of output equations, Specific Loadings: Selection of specific magnetic and electric loadings for EV applications, Magnetic Circuit Analysis: Air gap calculation, Carter's coefficient, real and apparent flux density, Winding Design: AC machine windings, distributed vs. concentrated, single/multi-layer.

Induction Motor (IM) Design
Rotor Design: End ring and rotor bar design for traction drives, Leakage Reactance: Calculation of slot and end ring leakage, FEM Analysis.

Permanent Magnet Synchronous Machine (PMSM/IPMSM)
Design Magnet Materials: High-temperature magnet properties and NdFeB characteristics, Rotor Design: Surface vs. Interior permanent magnet (IPMSM) design for high-speed rotors, Magnetic Circuit: Calculation of permanent magnet mmf and permeance coefficient, Cogging Torque & Torque Ripple: Reduction techniques (skewing, step skewing, pole shaping), Field Weakening: Designing for wide speed range (high RPM), FEM Analysis.

Learning Resources:

Text Books:

1. A.K. Sawhney, "A Course in Electrical Machine Design," Dhanpat Rai & Co. (P) Limited, 2016, 6th Edition.
2. M.G. Say, "Performance and Design of AC Machines," , CBS Publishers and Distributors Pvt. Ltd. 2002, 1st Edition.

Reference Books:

1. John G. Hayes, G. Abas Goodarzi, “Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles,” John Wiley & Sons Inc., 2018, 1st Edition.
2. R. Krishnan, “Electric Motor Drives Modeling, Analysis, and Control,” Pearson Education India, 2015, 1st Edition.

Online resources:

1. https://nptel.ac.in/courses/108102372

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/

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 of frogs 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	Analyse 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