MK UNIVERSITY

PATAN, GUJARAT

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MK University, Patan
Faculty of Engineering Technology,
Department of Electrical Engineering

M. TECH (ELECTRICAL ENGINEERING) SEM-I									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTEE101	ADVANCED MATHEMATICS FOR ENGINEERS	4	0	4	40	60	100
2	MAJOR	MTEE102	ADVANCED POWER SYSTEM ANALYSIS	4	2	6	90	60	150
3	MAJOR	MTEE103	RESEARCH METHDOLOGY & TECHNICAL COMMUNICATION	4	0	4	40	60	100
4	MINOR	MTEE104	POWER ELCETRONICS & DRIVES	4	2	6	90	60	150
5	SEC	MTEE105	ENTERPRENURSHIP DEVELOPMENT	4	0	4	40	60	100
TOTAL				20	4	24	300	300	600

M. TECH (ELECTRICAL ENGINEERING) SEM-II									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTEE201	SMART GRID TECHNOLOGIES	4	0	4	40	60	100
2	MAJOR	MTEE202	DIGITAL SIGNAL PROCESSING FOR POWER SYSTEMS	4	2	6	90	60	150
3	MAJOR	MTEE203	ELECTRICAL VEHICLE SYSTEMS	4	2	6	90	60	150
4	MINOR	MTEE204	ADVANCED CONTROL SYSTEMS	4	2	6	90	60	150
5	VAC	MTEE205	BUSINESS COMMUNICATION-I	2	0	2	0	50	50
TOTAL				18	6	24	310	290	600

M. TECH (ELECTRICAL ENGINEERING) SEM-III									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTEE301	HIGH VOLTAGE ENGINEERING	4	2	6	90	60	150
2	MAJOR	MTEE302	POWER SYSTEM PROTECTION & AUTOMATION	4	2	6	90	60	150
3	MINOR	MTEE303	MOOC/SWAYAM COURSE	3	0	3	100	00	100
4	VAC	MTEE304	DISSERTATION PHASE-I	0	8	8	100	100	200
TOTAL				11	12	23	380	220	600

M. TECH (ELECTRICAL ENGINEERING) SEM-IV									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	MTEE401	INDUSTRY SEMINARS/WORKSHOPS/INTERNSHIP	0	2	2	50	00	50
2	MINOR	MTEE402	COMPREHENSIVE VIVA VOCE	0	2	2	50	00	50
3	MAJOR	MTEE403	DISEERTATION PHASE-II	0	16	16	200	200	400
4	VAC	MTEE404	BUSINESS COMMUNICATION-II	2	0	2	00	50	50
TOTAL				2	20	22	300	250	550

SEMESTER-I

SUBJECT CODE: MTEE101

SUBJECT NAME: ADVANCED MATHEMATICS FOR ENGINEERS

Course Objectives:

- To provide a rigorous mathematical foundation for advanced engineering modeling and analysis.
- To bridge theoretical mathematics with practical engineering applications.
- To develop problem-solving skills using analytical and computational tools.
- To prepare students for research and development in engineering domains requiring mathematical sophistication.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and solve engineering problems using advanced techniques in linear algebra and tensor analysis.
CO2	Apply partial differential equations (PDEs) and transform methods to model dynamical systems and boundary value problems.
CO3	Use variational calculus and optimization methods for engineering design and control problems.
CO4	Analyze stochastic systems and uncertainty propagation using probability theory and statistical methods.

Unit	Content	Credit	Weightage
I	**Advanced Linear Algebra & Tensors for Engineers** ○ Review of vector spaces, eigenvalues, SVD, Jordan form ○ Matrix decompositions (LU, QR, Cholesky, Schur) ○ Tensor algebra: notation, operations, invariants ○ Tensor applications: stress-strain, inertia, constitutive models ○ Numerical linear algebra (conditioning, iterative solvers) • **Applications:** Structural analysis, continuum mechanics, control systems, data compression.	1	25%
II	**Partial Differential Equations & Transform Methods** ○ Classification of PDEs (elliptic, parabolic, hyperbolic) ○ Separation of variables, eigenfunction expansions ○ Green's functions for ODEs and PDEs ○ Integral transforms (Fourier, Laplace, Hankel) for PDEs ○ Introduction to finite element and finite volume concepts	1	25%

	• **Applications:** Heat transfer, wave propagation, fluid dynamics, signal processing.		
III	**Calculus of Variations & Optimization** ○ Functional derivatives, Euler–Lagrange equation ○ Constraints (Lagrange multipliers, isoperimetric problems) ○ Direct methods (Ritz, Galerkin) ○ Optimal control theory (Pontryagin's principle, Hamiltonian formulation) ○ Convex optimization basics (gradient descent, KKT conditions) • **Applications:** Optimal design, trajectory optimization, energy minimization, control systems.	1	25%
IV	**Stochastic Processes & Uncertainty Quantification** ○ Probability spaces, random variables, distributions ○ Stochastic processes (Brownian motion, Poisson process, Markov chains) ○ Itô calculus basics (stochastic differential equations) ○ Uncertainty quantification (Monte Carlo, polynomial chaos, sensitivity analysis) ○ Statistical estimation and regression for engineering data • **Applications:** Risk analysis, reliability engineering, random vibrations, financial engineering, signal noise modelling	1	25%

TEXT BOOKS:

- Kreyszig, E. – *Advanced Engineering Mathematics* (10th ed.) – Wiley.
- Strang, G. – *Linear Algebra and Its Applications* (5th ed.) – Cengage.
- Arfken, G.B., Weber, H.J., Harris, F.E. – *Mathematical Methods for Physicists* (7th ed.) – Academic Press.
- J.N. Reddy – *Applied Functional Analysis and Variational Methods in Engineering* – McGraw-Hill.
- Papoulis, A., & Pillai, S.U. – *Probability, Random Variables and Stochastic Processes* (4th ed.) – McGraw-Hill.

REFERENCE BOOKS:

- Riley, K.F., Hobson, M.P., Bence, S.J. – *Mathematical Methods for Physics and Engineering* (3rd ed.) – Cambridge.
- Gelfand, I.M., & Fomin, S.V. – *Calculus of Variations* – Dover.
- Oksendal, B. – *Stochastic Differential Equations: An Introduction with Applications* (6th ed.) – Springer.
- Holmes, M.H. – *Introduction to Numerical Methods in Differential Equations* – Springer.
- Gould, P. – *Introduction to Linear Elasticity* (for tensor applications) – Springer.

ONLINE RESOURCES:

- Coursera:
  - *Mathematics for Engineers Specialization* (The Hong Kong University of Science and Technology)
  - *Data Science Math Skills* (Duke University)

SUBJECT CODE: MTEE102

SUBJECT NAME: ADVANCED POWER SYSTEM ANALYSIS

Course Objectives:

- To provide an in-depth understanding of advanced modeling, analysis, and simulation techniques for modern power systems.
- To develop skills in power flow analysis, stability studies, and fault analysis for large-scale interconnected systems.
- To introduce advanced concepts such as optimal power flow, state estimation, and reliability analysis.
- To prepare students for research, design, and operation roles in power system planning and operation.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and solve power flow problems using advanced numerical methods for large-scale systems.
CO2	Analyze power system stability under transient and dynamic conditions.
CO3	Evaluate fault currents and protection schemes for symmetrical and unsymmetrical faults.
CO4	Apply optimization techniques for economic dispatch, optimal power flow, and system reliability assessment.

Unit	Content	Credit	Weightage
I	**Advanced Power Flow Analysis & Numerical Methods** • **Topics:** ○ Review of bus admittance and impedance matrices. ○ Newton-Raphson, Fast Decoupled, and Gauss-Seidel methods for power flow. ○ Sparsity techniques and optimal ordering. ○ Handling of PV buses, reactive power limits, and tap-changing transformers. ○ Contingency analysis and N-1 security. • **Applications:** Large-scale grid analysis, voltage stability assessment, contingency planning.	1	25%
II	**Power System Stability Analysis** • **Topics:** ○ Classification of stability: steady-state, transient, and dynamic. ○ Swing equation and equal area criterion. ○ Multi-machine stability analysis.	1	25%

	○ Small-signal stability: eigenvalue analysis and modal participation. ○ Power system stabilizers (PSS) and FACTS devices for stability enhancement. • **Applications:** Grid stability assessment, rotor angle stability, oscillation damping.		
III	**Fault Analysis & Protection Coordination** • **Topics:** ○ Symmetrical and unsymmetrical fault analysis using symmetrical components. ○ Sequence networks and fault impedance modeling. ○ Software-based fault analysis (ETAP, DigSILENT). ○ Protection coordination: overcurrent, distance, differential protection. ○ Arc flash analysis and safety standards. • **Applications:** Protection system design, short-circuit studies, arc flash hazard assessment.	1	25%
IV	**Optimal Power Flow & System Reliability** • **Topics:** ○ Economic dispatch: lambda iteration, gradient methods. ○ Optimal power flow (OPF): formulations and solution methods. ○ State estimation: weighted least squares, bad data detection. ○ Power system reliability: LOLP, ELCC, Monte Carlo simulation. ○ Integration of renewable energy sources in OPF and reliability studies. • **Applications:** Grid optimization, renewable integration, reliability-centered maintenance.	1	25%

TEXT BOOKS:

- Grainger, J.J., & Stevenson, W.D. – *Power System Analysis* – McGraw-Hill.
- Kundur, P. – *Power System Stability and Control* – McGraw-Hill.
- Saadat, H. – *Power System Analysis* – PSA Publishing.
- Wood, A.J., Wollenberg, B.F., & Sheblé, G.B. – *Power Generation, Operation, and Control* – Wiley.

REFERENCE BOOKS:

- Anderson, P.M., & Fouad, A.A. – *Power System Control and Stability* – Wiley-IEEE Press.
- Glover, J.D., Sarma, M.S., & Overbye, T.J. – *Power System Analysis & Design* – Cengage Learning.
- Abdelhay, A., & El-Hawary, M.E. – *Electrical Power Systems: Design and Analysis* – Wiley.
- Gönen, T. – *Modern Power System Analysis* – CRC Press.

ONLINE RESOURCES:

- NPTEL: *Power System Analysis* (IIT Kharagpur, IIT Bombay)
- Coursera: *Power System Analysis* (University at Buffalo)
- edX: *Electric Power Systems* (MITx, TU Delft)
- IEEE Xplore: Access to recent papers on OPF, stability, and smart grids

PRACTICAL LIST:

1. Power Flow Analysis using MATLAB/Simulink (Module 1)
   - *Task:* Develop a Newton-Raphson power flow program for a 5-bus system. Compare with ETAP/PSS®E results. Perform contingency analysis for line outages.
2. Transient Stability Simulation (Module 2)
   - *Task:* Simulate a 3-machine, 9-bus system in DigSILENT/PowerFactory. Apply a 3-phase fault and analyze rotor angle stability. Design a PSS and evaluate its performance.
3. Fault Analysis & Protection Coordination (Module 3)
   - *Task:* Using ETAP, model a 132/33 kV substation. Perform symmetrical and unsymmetrical fault studies. Design and coordinate overcurrent and distance protection schemes.
4. Optimal Power Flow & Reliability Assessment (Module 4)
   - *Task:* Solve an AC-OPF problem using MATPOWER/PYPSA. Incorporate wind and solar generation. Perform Monte Carlo simulation for reliability assessment (LOLP calculation).

SUBJECT CODE: MTEE103

SUBJECT NAME: RESEARCH METHDOLOGY AND TECHNICAL COMMUNICATION

Course Objectives:

- To equip engineering graduates with a structured approach to scientific inquiry and problem-solving.
- To develop proficiency in selecting and applying appropriate research methods for engineering investigations.
- To enhance technical communication skills for academia and industry.
- To foster an understanding of research ethics, scholarly publishing, and lifelong learning in research.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate a research problem, conduct systematic literature reviews, and develop a viable research proposal.
CO2	Design and execute appropriate research methodologies (experimental, numerical, analytical) with consideration for ethics and data integrity.
CO3	Apply statistical tools and software for data analysis, interpretation, and validation of research findings.
CO4	Produce high-quality technical documents (research papers, proposals, theses) and deliver effective technical presentations.

Unit	Content	Credit	Weightage
I	**Foundations of Engineering Research & Problem Formulation** • **Topics:** ○ Philosophy of research: inductive vs. deductive reasoning, scientific method in	1	25%

	engineering. ◦ Types of engineering research: fundamental, applied, experimental, computational, empirical. ◦ Problem identification and formulation: research gap analysis. ◦ Literature review strategies: databases (Scopus, Web of Science, IEEE Xplore), citation management tools (Zotero, Mendeley), critical analysis of literature. ◦ Developing a research proposal: objectives, scope, significance, and work plan. • **Applications:** Thesis topic selection, grant proposal writing, project planning.		
II	**Research Design, Methods & Ethics** • **Topics:** ◦ Research design: experimental, quasi-experimental, case study, modeling & simulation. ◦ Data collection methods: sensors, surveys, instrumentation, simulation outputs. ◦ Design of Experiments (DoE): factorial design, Taguchi methods, response surface methodology. ◦ Research ethics: plagiarism, fabrication/falsification, authorship, informed consent. ◦ Ethical approval process and responsible conduct of research (RCR). • **Applications:** Planning a lab/field experiment, setting up a CFD/FEA study, survey design.	1	25%
III	**Data Analysis, Statistics & Software Tools** • **Topics:** ◦ Data preprocessing: outlier detection, missing data, normalization. ◦ Descriptive and inferential statistics: hypothesis testing (t-test, ANOVA), confidence intervals. ◦ Regression analysis: linear, multiple, logistic. ◦ Introduction to multivariate analysis and machine learning for engineering data. ◦ Software tools: MATLAB/Python (NumPy, SciPy, pandas), R, MiniTab. ◦ Data visualization principles: effective graphs, charts, and plots. • **Applications:** Analyzing experimental results,	1	25%

	validating computational models, interpreting sensor data.		
IV	**Technical Communication & Research Dissemination** • **Topics:** ○ Structure of technical documents: research papers, theses, technical reports. ○ Writing strategies: clarity, conciseness, coherence, and argument development. ○ Graphical abstracts, data presentation, and table/figure design. ○ Oral presentations: conference talks, thesis defense, poster design. ○ Publication process: journal selection, peer review, responding to reviewers. ○ Intellectual Property Rights (IPR): patents, copyrights, licensing. ○ Research dissemination: repositories, academic social networks (ResearchGate, LinkedIn), and impact metrics (h-index, citations). • **Applications:** Paper writing, thesis compilation, conference presentation, patent filing.	1	25%

TEXT BOOKS:

- Kothari, C.R. – *Research Methodology: Methods and Techniques* (4th ed.) – New Age International.
- Day, R.A., and Gastel, B. – *How to Write and Publish a Scientific Paper* (9th ed.) – Greenwood.
- Montgomery, D.C. – *Design and Analysis of Experiments* (10th ed.) – Wiley.
- Alley, M. – *The Craft of Scientific Writing* (4th ed.) – Springer.

REFERENCE BOOKS:

- Bordens, K.S., and Abbott, B.B. – *Research Design and Methods: A Process Approach* (11th ed.) – McGraw-Hill.
- Wallwork, A. – *English for Writing Research Papers* (2nd ed.) – Springer.
- Box, G.E.P., Hunter, J.S., and Hunter, W.G. – *Statistics for Experimenters* (2nd ed.) – Wiley.
- IEEE Author Center Guides – *IEEE Publication Services and Products Board*.
- Laplante, P.A. – *Technical Writing: A Practical Guide for Engineers and Scientists* – CRC Press.

ONLINE RESOURCES:

- edX Courses:
  1. *"Principles of Statistical Analysis"* (Microsoft)
  2. *"How to Write and Publish a Scientific Paper"* (KU Leuven)

SUBJECT CODE: MTEE104

SUBJECT NAME: POWER ELECTRONICS AND DRIVES

Course Objectives:

- To provide an in-depth understanding of advanced power semiconductor devices, topologies, and modulation techniques.
- To analyze and design power electronic converters for AC/DC, DC/DC, and DC/AC applications.
- To model, control, and simulate electric motor drives for industrial and traction applications.
- To introduce emerging trends in wide-bandgap devices, renewable energy integration, and electric vehicle drives.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze and design advanced power electronic converters for various industrial applications.
CO2	Model and simulate electric motor drives using vector control and direct torque control techniques.
CO3	Design and implement modulation strategies for multilevel inverters and resonant converters.
CO4	Evaluate and integrate power electronic systems in renewable energy and electric vehicle applications.

Unit	Content	Credit	Weightage
I	**Advanced Power Semiconductor Devices & Converter Topologies** • **Topics:** ○ Wide-bandgap devices: SiC and GaN MOSFETs, diodes, and applications. ○ Soft-switching techniques: ZVS, ZCS, resonant converters. ○ Multilevel inverters: NPC, flying capacitor, cascaded H-bridge topologies. ○ Matrix converters and cycloconverters. ○ Thermal management and reliability of power devices. • **Applications:** High-frequency converters, renewable energy systems, industrial drives.	1	25%
II	**Modulation Techniques & Control of Power Converters** • **Topics:** ○ Advanced PWM techniques: space vector PWM, selective harmonic elimination. ○ Modulation for multilevel inverters. ○ Digital control implementation using DSP/FPGA. ○ Modeling and control of DC-DC converters: buck, boost, Cuk, SEPIC. ○ Power factor correction (PFC) techniques.	1	25%

	• **Applications:** Motor drives, UPS, active front-end converters.		
III	**Electric Motor Drives & Control Strategies** • **Topics:** ○ Modeling of AC motors: induction and synchronous machines. ○ Vector control (FOC) and direct torque control (DTC) of induction motors. ○ Permanent magnet synchronous motor (PMSM) drives. ○ Sensor less control techniques. ○ Traction drives and regenerative braking. • **Applications:** Industrial automation, electric vehicles, robotics.	1	25%
IV	**Applications in Renewable Energy & Electric Vehicles** • **Topics:** ○ Grid-connected inverters for solar and wind systems. ○ Battery charging/discharging converters (BMS integration). ○ Power electronic interfaces for EVs: onboard chargers, DC-DC converters. ○ Microgrid and energy storage system integration. ○ EMI/EMC considerations in power electronic systems. • **Applications:** Solar/wind integration, EV powertrains, smart grids.	1	25%

TEXT BOOKS:

- Rashid, M.H. – *Power Electronics: Circuits, Devices, and Applications* – Pearson.
- Bose, B.K. – *Modern Power Electronics and AC Drives* – Prentice Hall.
- Mohan, N., Undeland, T.M., & Robbins, W.P. – *Power Electronics: Converters, Applications, and Design* – Wiley.
- Krishnan, R. – *Electric Motor Drives: Modeling, Analysis, and Control* – Pearson.

REFERENCE BOOKS:

- Erickson, R.W., & Maksimović, D. – *Fundamentals of Power Electronics* – Springer.
- Kazmierkowski, M.P., Krishnan, R., & Blaabjerg, F. – *Control in Power Electronics* – Academic Press.
- Holtz, J. – *Advanced PWM and Predictive Control* – Springer.
- Emadi, A. – *Handbook of Automotive Power Electronics and Motor Drives* – CRC Press.

ONLINE RESOURCES:

- NPTEL: *Power Electronics* (IIT Kharagpur, IIT Madras)
- Coursera: *Power Electronics Specialization* (University of Colorado Boulder)
- edX: *Electric Vehicles and Mobility* (DelftX)
- IEEE Xplore: Journals on power electronics, drives, and renewable energy
- Simulation Tools: MATLAB/Simulink, PLECS, PSIM, LTspice, ANSYS Twin Builder

PRACTICAL LIST:

1. Design and Simulation of a Three-Phase Voltage Source Inverter (Module 1 & 2)
   - *Task:* Simulate a three-phase VSI with space vector PWM in MATLAB/Simulink or PLECS. Analyze harmonic spectrum and implement closed-loop control for output voltage regulation.
2. Vector Control of Induction Motor Drive (Module 3)
   - *Task:* Implement vector control of a 3-phase induction motor using DSP/FPGA or simulation tools. Tune PI controllers, plot speed/torque responses, and compare with DTC performance.
3. Design of a Bidirectional DC-DC Converter for EV Application (Module 4)
   - *Task:* Design a bidirectional buck-boost converter for battery charging/discharging in an EV. Simulate in PSIM/LTspice. Analyze efficiency, thermal performance, and control dynamics.
4. Grid-Connected Solar Inverter with MPPT (Module 4)
   - *Task:* Model a single-phase grid-connected PV inverter with MPPT (P&O/Incremental Conductance). Simulate grid synchronization, power flow control, and THD analysis as per IEEE 1547 standards.

SUBJECT CODE: MTEE105

SUBJECT NAME: ENTERPRENURSHIP DEVELOPMENT

Course Objectives:

- To cultivate an entrepreneurial mindset among engineering graduates.
- To provide practical tools for transforming technical ideas into viable business ventures.
- To develop skills in business modeling, financial planning, and venture funding.
- To prepare students for startup creation, intrapreneurship, or technology commercialization roles.

Course Outcomes: At the end of the course students shall be able to

CO1	Identify and evaluate entrepreneurial opportunities emerging from technological trends and market gaps.
CO2	Develop a comprehensive business model and validate it using lean startup methodologies and customer discovery.
CO3	Create financial projections, evaluate startup costs, and understand funding mechanisms for technology ventures.
CO4	Formulate a complete investor-ready business plan and deliver an effective pitch to potential stakeholders.

Unit	Content	Credit	Weightage
I	**Entrepreneurial Mindset & Opportunity Identification** • **Topics:** ○ The Entrepreneurial Engineer: Mindset, traits, and role in economic development. ○ Sources of Innovation: Technology push vs. market pull, disruptive vs. sustaining innovation. ○ Opportunity Recognition: Identifying	1	25%

	problems worth solving, trend analysis (STEEP), blue ocean strategy. ○ Idea Validation: Lean canvas, hypothesis testing, conducting problem-solution interviews. ○ Intellectual Property Strategy for Startups: Patents, trademarks, trade secrets, and licensing basics. • **Applications:** Spotting opportunities in cleantech, Industry 4.0, medtech, and digital transformation.		
II	**Business Model Design & Customer Development** • **Topics:** ○ Business Model Innovation: Business Model Canvas (Osterwalder), Value Proposition Canvas. ○ Customer Discovery & Validation: The "Get Out of the Building" approach, creating MVP (Minimum Viable Product). ○ Market Analysis: TAM, SAM, SOM, competitive analysis, positioning. ○ Pricing Strategies for Tech Products: Cost-plus, value-based, subscription, freemium models. ○ Go-to-Market Strategy: Sales channels, partnerships, digital marketing fundamentals. • **Applications:** Designing scalable models for SaaS, hardware-as-a-service, platform businesses.	1	25%
III	**Startup Finance, Funding & Legal Foundations** • **Topics:** ○ Startup Financials: Building financial models, unit economics, burn rate, runway. ○ Pro Forma Statements: Income statement, cash flow, balance sheet projections. ○ Funding Sources: Bootstrapping, angels, venture capital, crowdfunding, government grants (SBIR, DST). ○ Valuation Methods for Early-Stage Startups: Scorecard, Berkus, risk factor summation. ○ Legal Structures & Compliance: Company registration (LLP, Pvt Ltd), shareholder agreements, ESOPs, compliance essentials. ○ Term Sheet Fundamentals: Key clauses, negotiation basics.	1	25%

	• **Applications:** Preparing for seed funding, managing cash flow, cap table management.		
IV	**Business Planning, Pitching & Scaling Ventures** • **Topics:** ○ The Business Plan: Executive summary, company description, product/service, market analysis, marketing plan, management team, financial projections. ○ The Art of Pitching: Investor pitch deck structure, storytelling, demo preparation. ○ Building the Team: Co-founder selection, hiring early employees, advisory boards. ○ Operational Planning: Supply chain, quality, scaling production. ○ Growth Strategies: Scaling challenges, pivoting, exit strategies (acquisition, IPO). ○ Social Entrepreneurship & Ethics: Creating social impact, ethical leadership. • **Applications:** Crafting investor pitches, developing operational roadmaps, planning for scale.	1	25%

TEXT BOOKS:

- Osterwalder, A., and Pigneur, Y. – *Business Model Generation* – Wiley.
- Ries, E. – *The Lean Startup* – Penguin.
- Blank, S., and Dorf, B. – *The Startup Owner's Manual* – K & S Ranch.
- Barrow, C., Barrow, P., and Brown, R. – *The Business Plan Workbook* (10th ed.) – Kogan Page.

REFERENCE BOOKS:

- Aulet, B. – *Disciplined Entrepreneurship* – Wiley.
- Mullins, J. – *The New Business Road Test* (5th ed.) – FT Publishing.
- Kawasaki, G. – *The Art of the Start 2.0* – Portfolio Penguin.
- Thiel, P. – *Zero to One* – Crown Business.
- Maurya, A. – *Running Lean* (2nd ed.) – O'Reilly.

ONLINE RESOURCES:

- Coursera: *"Entrepreneurship Specialization"* (Wharton), *"Startup Entrepreneurship"* (Technion).
- edX: *"Entrepreneurship in Emerging Economies"* (HarvardX), *"Innovation and Entrepreneurship"* (DelftX).
- Udemy: Courses on Business Plan Writing, Startup Funding, and Digital Marketing.

SEMESTER-II

SUBJECT CODE: MTEE201

SUBJECT NAME: SMART GRID TECHNOLOGIES

Course Objectives:

- To introduce the architecture, components, and operational principles of modern smart grids.
- To analyze smart grid communication protocols, cybersecurity challenges, and data management systems.
- To explore advanced grid technologies including smart meters, demand response, distributed energy resources, and microgrids.
- To prepare students for roles in smart grid design, implementation, and policy development.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the architecture and components of smart grid systems and their interoperability.
CO2	Analyze communication networks, protocols, and cybersecurity measures in smart grids.
CO3	Evaluate smart metering infrastructure, demand-side management, and grid automation technologies.
CO4	Design and assess microgrid systems, renewable integration, and grid modernization strategies.

Unit	Content	Credit	Weightage
I	**Smart Grid Architecture & Fundamentals** • **Topics:** ○ Evolution from traditional grid to smart grid. ○ Smart grid architecture models (NIST, IEC, IEEE). ○ Key components: smart meters, sensors, actuators, and intelligent electronic devices (IEDs). ○ Interoperability and standards (IEC 61850, IEEE 2030). ○ Grid modernization drivers: reliability, efficiency, sustainability. • **Applications:** Grid planning, utility automation, national smart grid initiatives.	1	25%
II	**Communication Networks & Cybersecurity** • **Topics:** ○ Communication technologies: PLC, RF, Wi-Fi, ZigBee, cellular (5G, LTE). ○ Protocols: DNP3, Modbus, IEC 61850, IEEE 802 series. ○ SCADA and EMS systems in smart grids.	1	25%

	◦ Cybersecurity threats, vulnerabilities, and attack vectors. ◦ Standards and frameworks: NERC CIP, ISO/IEC 27001, NIST SP 800-82. • **Applications:** Secure grid communication, intrusion detection, cyber-physical system protection.		
III	**Smart Metering & Demand Response** • **Topics:** ◦ Advanced Metering Infrastructure (AMI) architecture. ◦ Time-of-use pricing, real-time pricing, and dynamic tariffs. ◦ Demand response programs: incentive-based and price-based. ◦ Load forecasting and energy management systems. ◦ Home Energy Management Systems (HEMS) and smart appliances. • **Applications:** Utility billing, peak load management, consumer engagement.	1	25%
IV	**Distributed Energy Resources & Microgrids** • **Topics:** ◦ Integration of renewables (solar, wind, storage) into the grid. ◦ Microgrid architecture: grid-connected and islanded modes. ◦ Energy storage systems: batteries, flywheels, supercapacitors. ◦ Vehicle-to-grid (V2G) and grid-to-vehicle (G2V) technologies. ◦ Grid resilience and self-healing capabilities. • **Applications:** Community microgrids, EV integration, rural electrification.	1	25%

TEXT BOOKS:

- Borlase, S. – *Smart Grids: Infrastructure, Technology, and Solutions* – CRC Press.
- Fang, X., Misra, S., Xue, G., & Yang, D. – *Smart Grid – The New and Improved Power Grid: A Survey* – IEEE Communications Surveys & Tutorials.
- Momoh, J.A. – *Smart Grid: Fundamentals of Design and Analysis* – Wiley-IEEE Press.
- Sioshansi, F.P. – *Smart Grid: Integrating Renewable, Distributed & Efficient Energy* – Academic Press.

REFERENCE BOOKS:

- Gungor, V.C., et al. – *Smart Grid Technologies: Communication Technologies and Standards* – IEEE Transactions on Industrial Informatics.
- Erol-Kantarci, M., & Mouftah, H.T. – *Smart Grid Communications and Networking* – Cambridge University Press.

- Kabalci, E., & Kabalci, Y. – *Smart Grids and Their Communication Systems* – Springer.
- National Institute of Standards and Technology (NIST) – *NIST Framework and Roadmap for Smart Grid Interoperability Standards*.

ONLINE RESOURCES:

- NPTEL: *Smart Grid Technology* (IIT Roorkee, IIT Kharagpur)
- Coursera: *Smart Grids and Electric Vehicles* (University of Colorado Boulder)
- edX: *Smart Grids: The Basics* (DelftX), *Micrograds and Distributed Energy Resources* (MITx)
- IEEE Xplore: Access to journals like *IEEE Transactions on Smart Grid*, *IEEE Power and Energy Magazine*

SUBJECT CODE: MTEE202

SUBJECT NAME: DIGITAL SIGNAL PROCESSING FOR POWER SYSTEMS

Course Objectives:

- To introduce fundamental DSP concepts and their application in power system monitoring, protection, and control.
- To analyze and design digital filters for power quality assessment, harmonic analysis, and disturbance detection.
- To apply signal processing techniques for phasor estimation, fault detection, and power system oscillations.
- To prepare students for advanced research and development in smart grid diagnostics, PMU applications, and real-time DSP implementation.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply discrete-time signal analysis and digital filtering techniques to power system signals.
CO2	Design and implement DSP algorithms for power quality monitoring and harmonic extraction.
CO3	Develop phasor estimation and frequency tracking algorithms for PMU applications.
CO4	Utilize DSP tools for fault detection, event classification, and oscillatory mode analysis in power networks.

Unit	Content	Credit	Weightage

I	**Fundamentals of DSP & Power System Signal Analysis**
	• **Topics:**
	  ○ Review of discrete-time signals and systems.
	  ○ Sampling theorem, aliasing, and anti-aliasing filters in power systems.
	  ○ Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) for voltage/current analysis.
	  ○ Windowing techniques and spectral leakage.
	  ○ Introduction to real-time DSP platforms (DSP kits, FPGA).
	• **Applications:** Signal acquisition, harmonic analysis, transient recording.
		1	25%

II	**Digital Filter Design for Power Quality** • **Topics:** ○ FIR and IIR filter design techniques. ○ Notch filters, bandpass filters, and adaptive filters for power quality enhancement. ○ Harmonic extraction using DFT, Kalman filtering, and wavelet transforms. ○ Detection of sags, swells, transients, and interruptions. ○ Total Harmonic Distortion (THD) calculation and standards (IEEE 519). • **Applications:** Power quality monitoring, harmonic filtering, event detection.	1	25%
III	**Phasor Estimation & Synchrophasor Technology** • **Topics:** ○ Phasor estimation algorithms: zero-crossing, DFT-based, least squares, and Kalman filter methods. ○ Phasor Measurement Units (PMUs): architecture, standards (IEEE C37.118). ○ Frequency and rate-of-change-of-frequency (ROCOF) estimation. ○ Time synchronization (GPS, IEEE 1588). ○ Wide-area monitoring and control applications. • **Applications:** PMU data analysis, grid stability assessment, oscillation detection.	1	25%
IV	**DSP Applications in Protection & Diagnostics** • **Topics:** ○ Fault detection and classification using wavelet transforms and neural networks. ○ Traveling wave-based fault location. ○ Power system oscillation modal analysis using Prony and Matrix Pencil methods. ○ Condition monitoring of transformers and rotating machines using DSP. ○ Real-time implementation on DSP/FPGA for protection relays. • **Applications:** Relay design, fault analysis, equipment diagnostics, grid resilience.	1	25%

TEXT BOOKS:

- Oppenheim, A.V., & Schafer, R.W. – *Discrete-Time Signal Processing* – Pearson.
- Phadke, A.G., & Thorp, J.S. – *Synchronized Phasor Measurements and Their Applications* – Springer.
- Santoso, S., Powers, E.J., & Grady, W.M. – *Electric Power Quality* – Springer.
- Machowski, J., Bialek, J., & Bumby, J. – *Power System Dynamics: Stability and Control* –

Wiley.

REFERENCE BOOKS:

- Bollen, M.H.J., & Gu, I.Y.H. – *Signal Processing of Power Quality Disturbances* – Wiley-IEEE Press.
- IEEE Standard C37.118.1-2011 – *IEEE Standard for Synchrophasor Measurements for Power Systems*.
- Kehtarnavaz, N., & Kim, N. – *Digital Signal Processing System Design* – Academic Press.
- Mallat, S. – *A Wavelet Tour of Signal Processing* – Academic Press.

ONLINE RESOURCES:

- NPTEL: *Digital Signal Processing* (IIT Madras), *Power System Protection* (IIT Roorkee)
- Coursera: *Digital Signal Processing* (École Polytechnique Fédérale de Lausanne)
- edX: *Signal Processing and Systems* (MITx), *Power System Analysis* (DelftX)
- IEEE Xplore: Journals on DSP applications in power systems, PMU technology, and power quality
- MATLAB/Simulink: DSP Toolbox, Signal Processing Toolbox, Simscape Electrical

PRACTICAL LIST:

1. Harmonic Analysis using FFT in MATLAB (Module 1 & 2)
   - *Task:* Acquire voltage/current signals from a simulated power system model. Apply FFT with different windowing functions (Hanning, Blackman) to compute harmonics. Compare with IEEE 519 limits and design a digital notch filter to suppress dominant harmonics.
2. Design of a Digital Protection Relay Algorithm (Module 3 & 4)
   - *Task:* Implement a discrete Fourier transform-based phasor estimation algorithm for overcurrent protection. Simulate fault conditions in PSCAD/EMTDC and test the algorithm’s speed and accuracy. Add frequency tracking for adaptive relaying.
3. PMU Simulation and Data Analysis (Module 3)
   - *Task:* Develop a PMU model in MATLAB/Simulink compliant with IEEE C37.118.1. Generate synchrophasor data for a multi-machine system under disturbance. Analyze frequency and angle deviations for event detection.
4. Wavelet-Based Fault Detection and Classification (Module 4)
   - *Task:* Use wavelet transform (Daubechies, Haar) to detect and classify faults (LG, LL, LLG, LLL) in a transmission line model. Extract features from wavelet coefficients and use a simple classifier (SVM or ANN) to identify fault type and location. Validate using real/simulated fault data.

SUBJECT CODE: MTEE203

SUBJECT NAME: ELECTRICAL VEHICLE SYSTEMS

Course Objectives:

- To provide a comprehensive understanding of electric vehicle (EV) architecture, components, and subsystems.
- To analyze EV powertrain design, energy storage systems, battery management, and charging technologies.
- To model and simulate EV performance, efficiency, and energy management strategies.
- To explore emerging trends in EV technology, V2G systems, and sustainable mobility integration.

Course Outcomes: At the end of the course students shall be able to

CO1	Design and analyze EV powertrain systems including motors,

	power electronics, and transmissions.
CO2	Evaluate and model battery systems, including performance, thermal management, and state estimation.
CO3	Develop and simulate energy management strategies for hybrid and full-electric vehicles.
CO4	Assess EV charging infrastructure, grid integration, and vehicle-to-grid (V2G) technologies.

Unit	Content	Credit	Weightage
I	**EV Architecture & Powertrain Design** • **Topics:** ◦ EV classifications: BEV, PHEV, HEV, FCEV. ◦ Powertrain components: traction motors, power converters, transmission systems. ◦ Motor types for EVs: PMSM, induction, switched reluctance. ◦ Power electronics in EVs: DC-DC converters, inverters, onboard chargers. ◦ Regenerative braking systems and efficiency analysis. • **Applications:** EV drivetrain design, performance simulation, component selection.	1	25%
II	**Energy Storage & Battery Management Systems** • **Topics:** ◦ Battery chemistries: Li-ion, Li-Po, solid-state, and beyond. ◦ Battery modeling: equivalent circuits, electrochemical models. ◦ State of charge (SOC), state of health (SOH), and state of power (SOP) estimation. ◦ Battery thermal management and safety systems. ◦ Battery management system (BMS) architecture and algorithms. • **Applications:** BMS design, battery pack integration, lifecycle analysis.	1	25%
III	**EV Modeling, Simulation & Energy Management** • **Topics:** ◦ Vehicle dynamics and energy consumption modeling. ◦ Simulation tools: ADVISOR, AVL CRUISE, MATLAB/Simulink. ◦ Energy management strategies: rule-based, optimization-based, adaptive control.	1	25%

	◦ Hybrid EV power-split control and optimization. ◦ Range estimation and real-world driving cycle analysis. • **Applications:** EV performance simulation, range optimization, control strategy development.		
IV	**Charging Infrastructure & Grid Integration** • **Topics:** ◦ EV charging technologies: AC, DC fast charging, wireless charging. ◦ Standards: CCS, CHAdeMO, GB/T, IEC 61851. ◦ Charging station design, grid impact, and load management. ◦ Vehicle-to-grid (V2G) and vehicle-to-home (V2H) systems. ◦ Smart charging, renewable integration, and policy frameworks. • **Applications:** Charging network planning, V2G implementation, grid stability studies.	1	25%

TEXT BOOKS:

- Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K.M. – *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles* – CRC Press.
- Emadi, A. – *Advanced Electric Drive Vehicles* – CRC Press.
- Pistoia, G., & Liaw, B. – *Behaviour of Lithium-Ion Batteries in Electric Vehicles* – Springer.
- Larminie, J., & Lowry, J. – *Electric Vehicle Technology Explained* – Wiley.

REFERENCE BOOKS:

- Chan, C.C., & Chau, K.T. – *Modern Electric Vehicle Technology* – Oxford University Press.
- Gao, D.W., Mi, C., & Emadi, A. – *Modeling and Simulation of Electric and Hybrid Vehicles* – SAE International.
- Salah, M., & Oukaour, A. – *Battery Management Systems for Electric Vehicles* – Springer.
- IEEE Standard 2030.1.1-2021 – *IEEE Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles*.

ONLINE RESOURCES:

- NPTEL: *Electric Vehicles* (IIT Bombay, IIT Madras)
- Coursera: *Electric Vehicles and Mobility* (École des Ponts ParisTech, Delft University)
- edX: *Electric Cars: Technology* (TU Delft), *Battery Storage Technologies* (University of Oxford)
- IEEE Xplore: Journals on EVs, battery tech, and V2G systems

PRACTICAL LIST:

1. EV Powertrain Simulation in MATLAB/Simulink (Module 1)
   - *Task:* Model a BEV powertrain with PMSM motor, inverter, and battery pack. Simulate acceleration, gradeability, and energy consumption over a standard driving cycle (e.g., WLTP, NEDC). Analyze efficiency and performance metrics.
2. Battery Modeling and SOC Estimation (Module 2)

   - *Task:* Develop a second-order equivalent circuit model of a Li-ion battery in MATLAB. Implement an Extended Kalman Filter (EKF) for SOC estimation. Validate with experimental/dataset charge-discharge cycles.
3. Energy Management Strategy for a PHEV (Module 3)
   - *Task:* Design a rule-based and an optimization-based (e.g., ECMS) energy management strategy for a plug-in hybrid EV. Simulate in ADVISOR or Simulink and compare fuel economy, emissions, and battery degradation.
4. DC Fast Charger Design & V2G Integration Study (Module 4)
   - *Task:* Simulate a 50 kW DC fast charging station with grid connection in PSIM/PSCAD. Analyze harmonics, power quality, and grid impact. Propose a V2G control scheme for peak shaving and frequency regulation.

SUBJECT CODE: MTEE204

SUBJECT NAME: ADVANCED CONTROL SYSTEMS

Course Objectives:

- To provide a rigorous foundation in modern control theory, including state-space analysis, optimal control, and robust control.
- To develop skills in designing and implementing advanced controllers for complex, multi-variable, and nonlinear systems.
- To apply digital control, adaptive control, and intelligent control techniques to real-world engineering systems.
- To prepare students for research and development in automation, robotics, power systems, and industrial control applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Model and analyze dynamic systems using state-space representations and linearization techniques.
CO2	Design optimal controllers using Linear Quadratic Regulator (LQR) and Kalman filtering methods.
CO3	Implement robust control strategies using H-infinity and μ-synthesis techniques.
CO4	Apply adaptive, nonlinear, and intelligent control methods to real-time control problems.

Unit	Content	Credit	Weightage

I	**State-Space Analysis & Modern Control Design**
	• **Topics:**
	  ○ State-space representation of continuous and discrete systems.
	  ○ Controllability, observability, and stability (Lyapunov methods).
	  ○ Pole placement and state feedback design.
	  ○ Observer design: full-order and reduced-order observers.
	  ○ Linearization of nonlinear systems.
	• **Applications:** Power system stabilization, robotic
		1	25%

	control, aerospace systems.		

II	**Optimal Control & Estimation**
	• **Topics:**
	  ○ Calculus of variations and Pontryagin's maximum principle.
	  ○ Linear Quadratic Regulator (LQR) and Linear Quadratic Gaussian (LQG) control.
	  ○ Kalman filtering: continuous and discrete forms.
	  ○ Model Predictive Control (MPC) basics.
	  ○ Applications in real-time optimization and tracking.
	• **Applications:** Trajectory optimization, process control, autonomous vehicles.
		1	25%

III	**Robust Control & Multivariable Systems**
	• **Topics:**
	  ○ Introduction to robustness and sensitivity.
	  ○ H-infinity control: mixed sensitivity problem, loop shaping.
	  ○ μ-synthesis for structured uncertainty.
	  ○ Singular Value Decomposition (SVD) and multivariable frequency response.
	  ○ Robust stability and performance analysis.
	• **Applications:** Flight control, power system damping, precision motion systems.
		1	25%

IV	**Adaptive, Nonlinear & Intelligent Control**
	• **Topics:**
	  ○ Adaptive control: model reference adaptive control (MRAC), self-tuning regulators.
	  ○ Nonlinear control: feedback linearization, sliding mode control.
	  ○ Introduction to intelligent control: fuzzy logic, neural networks, and neuro-fuzzy systems.
	  ○ Hybrid systems and event-triggered control.
	  ○ Real-time implementation on embedded platforms.
	• **Applications:** Robotics, renewable energy systems, industrial automation.
		1	25%

TEXT BOOKS:

- Ogata, K. – *Modern Control Engineering* – Pearson.
- Dorf, R.C., & Bishop, R.H. – *Modern Control Systems* – Pearson.
- Skogestad, S., & Postlethwaite, I. – *Multivariable Feedback Control: Analysis and Design* – Wiley.
- Khalil, H.K. – *Nonlinear Systems* – Prentice Hall.

REFERENCE BOOKS:

- Franklin, G.F., Powell, J.D., & Emami-Naeini, A. – *Feedback Control of Dynamic Systems* – Pearson.
- Zhou, K., & Doyle, J.C. – *Essentials of Robust Control* – Prentice Hall.
- Åström, K.J., & Wittenmark, B. – *Adaptive Control* – Dover Publications.
- Wang, L.X. – *A Course in Fuzzy Systems and Control* – Prentice Hall.

ONLINE RESOURCES:

- NPTEL: *Control Engineering* (IIT Bombay), *Nonlinear Control Systems* (IIT Kanpur)
- Coursera: *Control of Mobile Robots* (Georgia Tech), *Modern Robotics* (Northwestern University)
- edX: *Linear Control Systems* (MITx), *Robust Control* (ETH Zurich)
- IEEE Xplore: Journals on control theory, robotics, and automation
- MATLAB/Simulink: Control System Toolbox, Robust Control Toolbox, Simulink Control Design

PRACTICAL LIST:

1. State Feedback Controller Design for an Inverted Pendulum (Module 1)
    - *Task:* Model a rotary inverted pendulum in MATLAB/Simulink. Design a state feedback controller with pole placement. Simulate stabilization and disturbance rejection. Implement on a real-time platform (e.g., Arduino, dSPACE) if available.
2. LQR Controller for a DC Motor Speed Control (Module 2)
    - *Task:* Derive a state-space model of a DC motor. Design an LQR controller to regulate speed under load variations. Compare performance with PID control. Implement in real-time using a DSP/FPGA board.
3. Robust Controller Design for a Flexible Joint System (Module 3)
    - *Task:* Model a single-link flexible joint robot with parameter uncertainty. Design an H-infinity controller to achieve robust performance. Analyze stability margins and compare with classical control approaches using MATLAB Robust Control Toolbox.
4. Adaptive Sliding Mode Control for a Nonlinear System (Module 4)
    - *Task:* Implement sliding mode control for a nonlinear system (e.g., magnetic levitation, UAV). Introduce parameter variations and design an adaptive sliding mode controller. Simulate in Simulink and analyze chattering reduction and tracking performance.

SEMESTER-III

SUBJECT CODE: MTEE301

SUBJECT NAME: HIGH VOLTAGE ENGINEERING

Course Objectives:

- To provide an in-depth understanding of high voltage generation, measurement, and insulation systems.
- To analyze breakdown mechanisms in gases, liquids, and solids under high voltage stress.
- To design and test high voltage equipment, including transformers, cables, and switchgear.
- To prepare students for careers in power transmission, insulation coordination, and HV testing and diagnostics**.**

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the mechanisms of electrical breakdown in different dielectric media.
CO2	Design and analyze high voltage generation and measurement systems.
CO3	Evaluate insulation systems and perform HV testing as per IEC/IEEE standards.
CO4	Apply knowledge to design, maintain, and diagnose HV equipment in power systems.

Unit	Content	Credit	Weightage
I	**Breakdown Phenomena in Dielectrics** • **Topics:** ◦ Ionization processes and breakdown in gases: Townsend's theory, streamer theory. ◦ Breakdown in liquid dielectrics: suspended particle theory, bubble theory. ◦ Breakdown in solid dielectrics: intrinsic, thermal, electrochemical, and partial discharge mechanisms. ◦ Composite insulation systems and interfacial phenomena. ◦ Vacuum breakdown and high voltage in space applications. • **Applications:** Insulation design, gas-insulated switchgear, transformer oil testing.	1	25%
II	**High Voltage Generation & Measurement** • **Topics:** ◦ Generation of high AC, DC, and impulse voltages: Marx generator, Cockcroft-Walton circuit, resonant transformers.	1	25%

	○ Measurement techniques: sphere gaps, capacitive dividers, resistive dividers, Rogowski coils. ○ Digital measuring systems and data acquisition in HV labs. ○ Calibration and uncertainty analysis in HV measurements. ○ Safety practices in high voltage laboratories. • **Applications:** HV testing labs, calibration services, R&D in pulse power.		
III	**HV Testing & Insulation Coordination** ○ **Topics:** ▪ Type tests, routine tests, and field tests for HV equipment. ▪ Dielectric tests: power frequency, impulse, and partial discharge tests. ▪ Insulation coordination: BIL, SIL, protective devices (surge arresters). ▪ Non-destructive testing: Tan delta, dielectric spectroscopy, recovery voltage method. ▪ Standards: IEC 60060, IEEE Std 4, IEC 62271. ○ **Applications:** Transformer testing, cable diagnostics, substation design.	1	25%
IV	**HV Equipment & Applications** • **Topics:** ○ Design of power transformers, bushings, and instrument transformers. ○ High voltage cables: materials, design, and fault location techniques. ○ Gas-insulated switchgear (GIS) and solid-insulated switchgear. ○ Overhead line insulation: insulators, corona effects, and radio interference. ○ HV in renewable integration: HVDC transmission, offshore wind farms. • **Applications:** Transmission line design, substation engineering, renewable grid integration.	1	25%

TEXT BOOKS:

- Kuffel, E., Zaengl, W.S., & Kuffel, J. – *High Voltage Engineering: Fundamentals* – Newnes.
- Naidu, M.S., & Kamaraju, V. – *High Voltage Engineering* – McGraw-Hill.
- Husain, E., & Nasser, E. – *High Voltage Engineering: Theory and Practice* – CRC Press.
- Raja, K., & Thomas, M.J. – *High Voltage Engineering* – Pearson.

REFERENCE BOOKS:

- IEEE Std 4-2013 – *IEEE Standard for High-Voltage Testing Techniques*.
- IEC 60060 Series – *High-voltage test techniques*.
- Razevig, D.V. – *High Voltage Engineering* – MIR Publishers.
- Stone, G.C., Boulter, E.A., Culbert, I., & Dhirani, H. – *Electrical Insulation for Rotating Machines* – Wiley-IEEE Press.

ONLINE RESOURCES:

- NPTEL: *High Voltage Engineering* (IIT Kharagpur, IIT Roorkee)
- Coursera: *Electrical Power Systems* (University at Buffalo) – includes HV modules
- edX: *Electric Power Systems* (MITx) – transmission and insulation topics
- IEEE Xplore: Journals on *IEEE Transactions on Dielectrics and Electrical Insulation*, *IEEE Power Delivery*
- Simulation Tools: COMSOL Multiphysics (for field analysis), PSCAD (for surge studies)

PRACTICAL LIST:

1. Breakdown Voltage Measurement in Transformer Oil (Module 1)
   - *Task:* Measure AC breakdown voltage of transformer oil using a test cell as per IEC 60156. Analyze the effect of moisture and contaminants. Plot Weibull distribution for breakdown probability.
2. Generation and Measurement of Impulse Voltages (Module 2)
   - *Task:* Set up a Marx generator to produce standard lightning impulse (1.2/50 µs). Measure using a capacitive divider and digital storage oscilloscope. Calibrate the measurement system and analyze waveform parameters.
3. Partial Discharge Detection in HV Insulation (Module 3)
   - *Task:* Detect and locate partial discharges in a model cable joint using a PD detector. Analyze PD patterns (phase-resolved PD) and correlate with insulation defects. Follow IEC 60270 standards.
4. Insulation Coordination Study for a Substation (Module 4)
   - *Task:* Perform insulation coordination for a 220 kV substation using software like EMTDC/PSCAD. Determine BIL levels, select surge arrester ratings, and evaluate protective margins. Simulate lightning and switching surges.

SUBJECT CODE: MTEE302

SUBJECT NAME: POWER SYSTEM PROTECTION AND AUTOMATION

Course Objectives:

- To provide an advanced understanding of protection principles, relay technologies, and automation systems in modern power networks.
- To analyze and design protection schemes for generation, transmission, distribution, and industrial systems.
- To integrate digital relays, communication networks, and automation systems for smart grid applications.
- To prepare students for roles in protection engineering, grid automation, and system resilience planning.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze fault conditions and design protection schemes for various power system components.
CO2	Apply numerical relay principles, settings, and coordination techniques.
CO3	Integrate communication protocols and automation systems for substation and wide-area protection.
CO4	Evaluate and implement protection systems for renewable integration, microgrids, and industrial networks.

Unit	Content	Credit	Weightage
I	**Fundamentals of Power System Protection** • **Topics:** ○ Protection objectives: selectivity, speed, reliability, sensitivity. ○ Symmetrical components and fault analysis (LG, LL, LLG, LLL). ○ Current and voltage transformers: characteristics, saturation, and transient response. ○ Overcurrent protection: inverse-time, definite-time, directional overcurrent relays. ○ Introduction to numerical relays and IEC 61850 architecture. • **Applications:** Relay coordination, fault analysis, CT/VT selection.	1	25%
II	**Transmission Line & Transformer Protection** • **Topics:** ○ Distance protection: principle, zones, characteristics (mho, quadrilateral). ○ Pilot protection: differential, phase comparison, and communication-assisted schemes.	1	25%

	○ Transformer protection: differential, overcurrent, restricted earth fault, Buchholz relay. ○ Reactor, capacitor, and busbar protection. ○ Auto-reclosing and synchrocheck. • **Applications:** EHV line protection, substation transformer protection, grid stability.		
III	**Generation & Distribution System Protection** • **Topics:** ○ Generator protection: differential, stator/rotor fault, loss of excitation, out-of-step. ○ Motor protection: thermal overload, starting protection, phase unbalance. ○ Distribution protection: fuse-recloser coordination, sectionalizers. ○ Arc flash hazard analysis and mitigation. ○ Protection in DG-integrated networks (inverter-based resources). • **Applications:** Plant protection, industrial systems, renewable integration.	1	25%
IV	**Automation & Smart Protection Systems** • **Topics:** ○ Substation automation: SCADA, RTU, IEDs, HMI. ○ Communication protocols: IEC 61850 (GOOSE, SV, MMS), DNP3, Modbus. ○ Wide-area protection and control (WAPC): system integrity protection schemes (SIPS). ○ Cyber-security in protection systems (IEC 62443, NERC CIP). ○ Adaptive protection for microgrids and active distribution networks. • **Applications:** Smart substations, grid automation, adaptive relaying, cyber-secure protection.	1	25%

TEXT BOOKS:

- Blackburn, J.L., & Domin, T.J. – *Protective Relaying: Principles and Applications* – CRC Press.
- Anderson, P.M. – *Power System Protection* – Wiley-IEEE Press.
- Horowitz, S.H., & Phadke, A.G. – *Power System Relaying* – Wiley.
- Ziegler, G. – *Numerical Distance Protection* – Siemens/Publicis.

REFERENCE BOOKS:

- IEEE Std C37.90 – *Relays and Relay Systems Associated with Electric Power Apparatus*.
- IEC 61850 Series – *Communication Networks and Systems for Power Utility Automation*.
- Mozina, C.J. – *Protection of Electricity Distribution Networks* – IET.

- Kumar, A., & Kumar, J. – *Digital Protection and Automation* – Khanna Publishers.

ONLINE RESOURCES:

- NPTEL: *Power System Protection* (IIT Roorkee, IIT Kharagpur)
- Coursera: *Power System Protection and Control* (University at Buffalo)
- edX: *Protection and Control of High Voltage Power Systems* (DelftX)
- IEEE Xplore: Journals on *IEEE Transactions on Power Delivery*, *IEEE Power Engineering Letters*
- Simulation Tools: ETAP, PSCAD/EMTDC, MATLAB/Simulink, OMICRON Test Universe
- Open-Source: RTDS/OPAL-RT libraries, IEC 61850 open-source stacks (libIEC61850)

PRACTICAL LIST:

1. Overcurrent Relay Coordination using ETAP/ASPEN (Module 1)
   - *Task:* Model a radial distribution network in ETAP. Coordinate IDMT overcurrent relays for feeders and transformers. Generate time-current coordination curves and validate selectivity.
2. Distance Relay Testing using Real-Time Simulator (Module 2)
   - *Task:* Configure a numerical distance relay (SEL, ABB, or Siemens). Test zone settings (Z1, Z2, Z3) using a real-time simulator (OPAL-RT/RTDS) for different fault types and locations. Analyze tripping times and characteristics.
3. Generator Differential Protection Simulation (Module 3)
   - *Task:* Model a synchronous generator in MATLAB/Simulink or PSCAD. Implement a percentage differential relay (87G). Simulate internal and external faults. Evaluate stability during CT saturation and high-impedance faults.
4. IEC 61850-Based Substation Automation (Module 4)
   - *Task:* Configure a small IEC 61850 substation automation system using OMICRON Test Universe or similar. Simulate GOOSE messaging for breaker failure protection. Implement a simple SCADA-HMI interface for monitoring and control.