TECHNO INDIA UNIVERSITY
WEST BENGAL

Department of Electrical Engineering

Syllabus for M. Tech. in Electrical Engineering

Specialization: Power Systems

First Year: First Semester

Sl.	Subject Code	Subject	Periods per week			Credits
			L	T	P	
Theory						
1	TIU-PMA-T115	Advanced Numerical Analysis	3	1	0	4
2	TIU-PEE-T121	Advanced power system analysis	3	1	0	4
3	TIU-PEE-T123	Advanced High Voltage Engineering	3	1	0	4
4	TIU-PEE-T105	Advanced Control Systems	3	1	0	4
5.	TIU-PEE-T127	Condition monitoring of power equipment	3	1	0	4
Practical						
1	TIU-PEE-L105	Advanced power system Lab	0	0	3	2
2	TIU-PEE-S101	Seminar	0	0	3	2
Sessional						
1	TIU-PES-S199	Entrepreneurship Skill Development	-	-	-	2
Total						**26**

Program: M. Tech in EE	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: ADVANCED NUMERICAL ANALYSIS	**Subject Code:** TIU-PMA-T115

Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Learning the Numerical techniques to obtain approximate solutions of various mathematical problems which cannot be solved analytically.

COURSE OUTCOME:

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

CO-1:	To solve a system of linear equations through direct methods.	K3
CO-2:	To deduce a system of linear equations through indirect methods.	K4
CO-3:	To calculate eigen value problem.	K4
CO-4:	To apply numerical methods to approximate a function.	K3
CO-5:	To deduce least square curve fitting.	K4
CO-6:	To examine numerical solution of initial value problems.	K4

COURSE CONTENT:

MODULE 1:		**8 Hours**
Solution of Simultaneous Linear Equations - Direct Methods – Gauss Elimination, Gauss Jordan, LU Decomposition, Matrix Inversion.		
MODULE 2:		**8 Hours**
Iterative Methods – Gauss - Jacobi, Gauss – Seidel		
MODULE 3:		**4 Hours**
Relaxation method. Necessary and sufficient conditions for convergence. Speed of convergence. (Proofs not required) S.O.R. and S.U.R. methods. Gerschgorin's circle theorem. (Statement only).		
MODULE 4:		**5 Hours**
Eigen value problem – Numerical largest value, Determination of eigen value by iterative methods.		
MODULE 5:		**5 Hours**
Quadratic Approximation, Cubic Spline Interpolation.		
MODULE 6:		**7 Hours**
Least Square Curve Fitting, nonlinear regression		
MODULE 7:		**8 Hours**
Numerical solution of initial value problems by Euler, Modified Euler, Runge-Kutta and Predictor-Corrector method.		
TOTAL LECTURES		**45 Hours**

Text Books:

1. Dr. B. S. Grewal – Numerical Methods in Engineering and Science
2. K Das – Numerical Methods

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Program: M. Tech. in EE	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Advanced Power system Analysis	**Subject Code:** TIU-PEE-T121
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand basic analytical tools.
2. analyze a power network for different operating conditions.
3. develop suitable techniques to assess the power network.

COURSE OUTCOME:

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

CO-1:	To perform and analyze load flow studies using different computational techniques as well as identify and understand the characteristics of ill-conditioned systems.	K4, K2
CO-2:	To understand the optimal VAR control problem and its significance in power system operation and stability and apply various solution methods for optimal power flow.	K2, K3
CO-3:	To apply different techniques to problems on fault studies (e.g. symmetrical faults, unsymmetrical faults).	K3
CO-4:	To understand different types of estimators and the necessicity of conducting state estimation.	K2
CO-5:	To understand Short-term, medium-range and long-term forecasting and various load forecasting methods.	K2
CO-6:	To analyze real-world case studies that illustrate the application of security analysis.	K4

COURSE CONTENT:

MODULE 1:	**LOAD FLOW STUDIES**	**10 Hours**
Power System Load Flow: Fast decoupled load flow, ill-conditioned system. Solution of load flow for ill-conditioned system. Distribution system load flow: Backward-forward, sequence component based power-flow, Direct approach to distribution system power flow. Sparse Matrix Techniques, Optimal ordering.		
MODULE 2:	**OPTIMAL POWER FLOW**	**12 Hours**
Optimal VAr control problem, controllable variables- Transformer taps, Generator voltages, Switchable shunt capacitors and Reactors, Objective functions, network performance constraints, constraints on state variables, Mathematical formulation, Solution of the Optimal Power Flow- The Gradient Method, Newton's Method, Linear Sensitivity Analysis, Linear Programming Methods, Security-Constrained Optimal Power Flow.		

MODULE 3:	**FAULT ANALYSIS**	**8 Hours**
Fault Studies: Z-Bus formation, Symmetrical faults, Unsymmetrical faults, concept of sequence components, koga components. Unsymmetrical fault studies using sequence components and Koga components. Open circuit fault analysis.		
MODULE 4:	**STATE ESTIMATION**	**4 Hours**
Types of estimators–static, dynamic, tracking estimators. Least Squares and Weighted Least squares estimation, formulation, solution techniques, Bad data identification and detection.		
MODULE 5:	**LOAD FORECASTING**	**4 Hours**
Load forecasting: Types-Short-term, medium-range, long-term forecasting, Classification and factors affecting load demand, Load forecasting methods.		
MODULE 6:	**POWER SYSTEM SECURITY**	**6 Hours**
Security analysis, Security assessment, Credible and incredible contingencies, Contingency identification and Contingency ranking, Security Calculation procedures.		
TOTAL LECTURES		**44 Hours**

Text Books:

1. Power system Analysis by Charles A. Gross: John Wiley & Sons.
2. Power system Analysis by John J. Grainger & William D. Stevenson, JR: Tata McGraw- Hill Edition.
3. Power system Analysis Operation and control by Abhijit Chakrabarti & Sunita Halder: Prentice-Hall of India, New Delhi-110001.
4. Computer techniques in Power System Analysis by M.A.Pai, TMH, Second Edition.
5. Power generation, operation, and control, Allen J. Wood, Bruce F, Wollenberg

Program: M. Tech. in EE	**Year, Semester:** 1st Year, 1st Sem
Course Title: Advanced High Voltage Engineering	**Subject Code:** TIU-PEE-T123
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

This course enables the students:

1. To understand the physics of breakdown mechanisms in solid, liquid and gaseous insulation
2. To learn various types of high voltage generation techniques,
3. To learn high voltage measurement techniques and
4. To be exposed to high voltage testing techniques as per industrial standard specifications, followed in any standard reputed high voltage generation, measurement and testing laboratory.

5. To learn lighting surges and switching impulse voltages and currents travelling through various power apparatus and corresponding overvoltage protection devices required with insulation coordination.

COURSE OUTCOME:

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

CO-1:	To understand the mechanism of high voltage A.C, high voltage D.C and impulse voltage generation.	K1, K2
CO-2:	To understand the basic mechanisms of breakdown phenomenon in solid, liquid and gaseous insulation.	K2
CO-3:	To understand high voltage measurement techniques.	K3
CO-4:	To understand the high voltage testing techniques.	K4
CO-5:	To understand the concept of overvoltage protection and insulation coordination.	K3
CO-6:	To understand phenomenon of lighting surges and switching impulse voltages and currents travelling through various power apparatus	K2

COURSE CONTENT:

MODULE 1:	**High Voltage generation**	10 hours
Generation of High Voltage: Generation of high AC voltages: Testing transformer, Cascaded transformer, Series resonant circuit, single stage and multi stage. Advantages of Series Resonant Circuit in testing of cables. Generation of DC high voltage: Cockcroft Walton doubler and multistage circuit. Van de Graph generator. Definition of Impulse Voltage as per Indian Standard Specification, Wave front and wave tail time, Generation of Impulse Voltage, Multistage Impulse generator, triggering of Impulse Generator.		
MODULE 2:	**Breakdown phenomena**	10hours
Breakdown of Gases: Mechanism of Breakdown of gases, Charge multiplication, Secondary emission, Townsend Theory, Streamer Theory, Paschen's Law, Determination of Minimum breakdown voltage, Breakdown in non-uniform field, Effect of polarity on corona inception and break down voltage. Partial Discharge: definition and development in solid dielectric. Break Down of Solids: Intrinsic breakdown, electromechanical break down, electrochemical breakdown, Thermal breakdown, Streamer Breakdown. Breakdown of Liquid: Intrinsic Break down, Cavitation Theory, Suspended particle Theory. Electronic breakdown. Breakdown in Vacuum: Nonmetallic electron emission mechanism, Clump mechanism, Effect of pressure on breakdown voltage. Breakdown in SF6 and other electronegative gases.		
MODULE 3:	**Measurement of High Voltage and High Current**	09 hours
Sphere gap voltmeter, AC, DC and impulse high voltage measurement as per Indian Standard		

Specifications, Potential dividers and Peak voltmeters for measurement of high AC voltage in conjunction with capacitance dividers. Capacitance Voltage Transformer, Rotating Voltmeter for the measurement of DC high voltage, Electrostatic Voltmeter. Measurement of Impulse currents; Rogowski coil and Magnetic potentiometer. Measurement of very high direct current.		
MODULE 4:	**High Voltage Testing**	07 hours
High Voltage Testing as per Indian Standard Specifications. High voltage testing of Insulators, Power cables, Bushings, Power capacitors, Transformers and Circuit breakers, Partial discharge testing of cables and transformers.		
Module 5:	**Overvoltage protection and Insulation coordination**	06 hours
Lightning Phenomena, Electrification of cloud, Development of Lightning Stroke, lightning induced over voltage, direct stroke, indirect stroke. Protection of Electrical Apparatus against over voltage, Lightning Arrestors, Valve Type, Metal Oxide arresters, Expulsion type. Insulation Coordination, Basic Insulation level. Basic Impulse level, Lightning and Switching Impulse level. Volt-time characteristics of protective devices, Determination of Basic Impulse level of substation equipment.		
TOTAL LECTURES		**42 Hours**

Reference Books:

1. High Voltage Engineering by Kuffel &Zaengl
2. High Voltage Measurement Techniques by A.J. Schwab
3. High Voltage Engineering by D.V. Razevig
4. High Voltage Engineering by M,S, Naidu and V. Kamaraju
5. High Voltage Engineering by C.L. Wadhwa

Program: M. Tech. in EE	**Year, Semester:** 1st Yr. 1st Sem.
Course Title: ADVANCED CONTROL SYSTEMS	**Subject Code:** TIU-PEE-T105
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. To understand the state-space representation of linear and nonlinear systems and analyze their properties like controllability and observability.
2. To design state feedback controllers and observers for linear systems and apply optimal control strategies such as Linear Quadratic Regulator (LQR) and Kalman Filter.
3. To explore advanced control techniques including feedback linearization, model reference adaptive control, and sliding mode control for nonlinear systems.

COURSE OUTCOME:

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

CO-1:	Understand state-variable representation of linear systems and convert transfer functions into canonical state-space forms.	K1
CO-2:	Analyze controllability and observability of linear systems.	K2
CO-3:	Solve state equations and design state feedback controllers and observers.	K3
CO-4:	Apply optimal control techniques such as Linear Quadratic Regulator (LQR) and Kalman Filter.	K4
CO-5:	Represent and analyze nonlinear systems in state-space, including phase-plane analysis.	K3
CO-6:	Implement advanced control techniques like feedback linearization, model reference adaptive control, and sliding mode control.	K4

COURSE CONTENT:

MODULE 1:	**State-Space Representation of Linear Systems**	**10 Hours**
State variable representation of LTI systems - Conversion of transfer functions to canonical state variable forms - Solution of state equations.		
MODULE 2:	**Controllability, Observability, and State Feedback Design**	**10 Hours**
Controllability and observability - Linear state variable feedback - Observer design.		
MODULE 3:	**Optimal Control and Estimation**	**8 Hours**
Linear Quadratic Regulator (LQR) - Kalman Filter.		
MODULE 4:	**Nonlinear System Representation and Stability**	**8 Hours**
Representation of nonlinear systems in state space - Phase plane analysis – Variable structure systems - Lyapunov's stability theorems.		
MODULE 5:	Advanced Control Techniques	**6 Hours**
Feedback linearization - Model reference adaptive control - Sliding mode control.		
TOTAL LECTURES		**42 Hours**

Books:

1. "Modern Control Engineering" by Ogata, Katsuhiko
2. "Control System Design" by Graham C. Goodwin, Stefan F. Graebe, and Mario E. Salgado
3. "Control Systems: Engineering and Design" by M. Gopal
4. "Adaptive Control" by Karl J. Åström and Björn Wittenmark
5. "Nonlinear Control Systems" by Hassan K. Khalil

Program: M. Tech. in EE	**Year, Semester:** 1st Yr., 1st Sem.

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Course Title: Condition Monitoring of Power Equipment	**Subject Code:** TIU-PEE-T127
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand basic diagnostic tools and the necessity of testing standards
2. detect contamination flashover and impulse faults.

COURSE OUTCOME:

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

CO-1:	Develop a comprehensive understanding of insulation systems in high voltage applications and the importance of diagnostic testing.	K2
CO-2:	Understand the significance of electrical and chemical tests for assessing the condition of insulation materials.	K2
CO-3:	Understand the necessity and application of testing standards.	K2
CO-4:	Understand the significance of Advanced Dielectric Measurements.	K2
CO-5:	Analyze test results for detection of contamination flashover.	K4
CO-6:	Apply techniques to detect impulse faults	K3

COURSE CONTENT:

MODULE 1:	**DIAGNOSTIC TESTS**	**12 Hours**
Introduction, Brief overview of transformer insulation, Degradation of oil-paper insulation system, Degradation of oil, Degradation of paper, Chemical Diagnostic tests, Dissolved gas analysis (DGA), Degree of Polymerization Measurement, Furan Analysis, Conventional Electrical Diagnostic Tests, Insulation resistance test, Polarization index test, C-tanδ test.		
MODULE 2:	**ASSESSMENT OF CONDITION**	**12 Hours**
Dielectric spectroscopy measurement, Polarization Depolarization current (PDC) measurement, Return Voltage Measurement (RVM), Frequency domain spectroscopy (FDS) measurement Advantages of FDS measurement over time domain measurements		
MODULE 3:	**STANDARD TESTS**	**10 Hours**
Need for testing standards – Standards for porcelain / Glass insulator – Classification of porcelain / glass insulator tests- Tests for cap and pin porcelain/ Glass insulators. High voltage AC testing methods, power frequency tests- Over voltage tests on insulators, Isolators, Circuit Breakers and power cables.		
MODULE 4:	**CONTAMINATION**	**6 Hours**
Contamination flashover phenomena-Contamination Severity- Artificial contamination tests, Laboratory testing versus in-service performance-Case study.		

MODULE 5:	IMPULSE TESTING	4 Hours
Impulse Testing: Impulse testing of transformers, Detection and classification of Impulse Faults.		
TOTAL LECTURES		44 Hours

Text Books:

1. T. K. Saha and P. Purkait, "Transformer Ageing: Monitoring and Estimation Techniques", (1st Edition) John Wiley and Sons, 2017
2. S. Chakravorti, D. Dey and B. Chatterjee," Recent Trends in the Condition Monitoring of Transformers-Theory, Implementation and Analysis", (1st Edition) Springer-Verlag London, 2013

Program: M. Tech. in EE	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Advanced Power System Lab	**Subject Code:** TIU-PEE-L105
Contact Hours/Week: 0–0–3 (L–T–P)	**Credit: 2**

COURSE OBJECTIVE:

Enable the student to:

1. Implement and understand different power flow algorithms
2. Understand effect of faults and assess system stability
3. Conduct state-estimation and identify bad-data

COURSE OUTCOME:

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

CO-1:	Model improved load flow techniques for transmission system	K4
CO-2:	Model improved load flow techniques for distribution system	K4
CO-3:	Understand the significance of optimal power flow techniques	K2
CO-4:	Understand the effect of faults on network dynamics	K2
CO-5:	Assess voltage stability of power networks and compare different metrics	K4
CO-6:	Implement state estimation and identify bad-data	K5

COURSE CONTENT:

Experiment 1	Fast decoupled load flow	6 Hours
Implement fast decoupled load flow. Compare convergence with NRLF for ill-conditioned networks.		
Experiment 2	**Backward forward load flow**	**6 Hours**
Implement backward-forward algorithm for distribution networks. Model voltage regulators.		

Experiment 3	**Newton's method of OPF**	**3 Hours**
Run OPF with the objective of economic dispatch for standard IEEE networks.		
Experiment 4	**Load flow with VAR control**	**9 Hours**
Model FACTS devices like STATCOM and SVC in load flow. Assess voltage stability using different metrics. Compare the metrics.		
Experiment 5	**Continuation Load flow to obtain PV curve**	**3 Hours**
Run continuation load flow to obtain PV curves with and without VAR control devices.		
Experiment 6	**Symmetrical fault analysis**	**3 Hours**
Simulate Symmetrical faults at different locations and obtain critical clearing time.		
Experiment 7	**Asymmetrical fault analysis**	**3 Hours**
Simulate Symmetrical faults at different locations		
Experiment 8	**State Estimation**	**9 Hours**
Implement and run state estimation and identify bad-data.		
TOTAL LAB HOURS		**42 Hours**

Text Books:

1. Power system Analysis Operation and control by Abhijit Chakrabarti & Sunita Halder: Prentice-Hall of India, New Delhi-110001.
2. Computer techniques in Power System Analysis by M.A.Pai, TMH, Second Edition.
3. Power generation, operation, and control, Allen J. Wood, Bruce F, Wollenberg

Program: M. Tech. in EE	**Year, Semester:** 1st Yr. 1st Sem.
Course Title: Seminar	**Subject Code:** TIU-PEE-S101
Contact Hours/Week: 0–0–3 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE:

Enable the student to:

1. To equip students with the ability to conduct in-depth literature surveys on specialized topics.
2. To develop analytical and critical thinking skills for evaluating existing research and identifying research gaps.
3. To enhance students' communication and presentation skills for effectively conveying technical content.

COURSE OUTCOME:

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

CO-1:	Conduct comprehensive literature surveys regarding a specific research	K1

	topic.	
CO-2:	Analyze and evaluate the literature available on the topic.	K2
CO-3:	Develop presentation and teaching skills to convey an idea.	K3
CO-4:	Identify research gaps in the studied literature.	K3
CO-5:	Design a structured seminar based on research findings.	K4
CO-6:	Formulate conclusions and propose future research directions.	K4

COURSE CONTENT:

MODULE 1:	**Introduction to Research**	**9 Hours**
Overview of research methodologies - Importance of literature review - Identifying key sources of information		
MODULE 2:	**Literature Survey and Data Collection**	**6 Hours**
Effective searching techniques - Evaluating research quality - Organizing research data		
MODULE 3:	**Critical Analysis of Research Papers**	**9 Hours**
Understanding research methodologies - Identifying gaps in existing research - Comparing different approaches		
MODULE 4:	**Presentation Techniques and Communication Skills**	**6 Hours**
Structuring a technical seminar - Effective verbal and visual communication - Handling audience questions		
MODULE 5:	**Research Gap Analysis and Future Scope**	**6 Hours**
Identifying new research areas - Formulating hypotheses - Writing research conclusions		
MODULE 6:	**Seminar and Report Writing**	**9 Hours**
Structuring a research report - Citation and referencing techniques - Preparing for final seminar delivery		
TOTAL LECTURES		**45 Hours**

First Year: Second Semester

Sl	**Subject Code**	**Subject**	**Contacts**			**Credits**
			L	**T**	**P**	
Theory						
1.	TIU- PCS-T120	Machine Learning	3	1	0	4

2.	TIU-PEE-T106	Power electronics application in EHV transmission (**FACTS and HVDC)**	3	1	0	4
3.	TIU-PEE-T108	Reliability Engineering	3	1	0	4
4.	TIU-PEE-T128	Overvoltage protection and Insulation coordination	3	1	0	4
5.	TIU-PEE-T130	Power system operation and control	3	1	0	4
Practical						
1	TIU-PEE-L124	Term paper leading to thesis	0	0	3	2
2	TIU-PEE-S102	Seminar	0	0	3	2
Sessional						
1	TIU-PES-S198	Entrepreneurship Skill Development	-	-	-	2
Total						**26**

Program: M. Tech. in EE	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Machine Learning	**Subject Code:** TIU-PCS-T120
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. Understand linear classification methods and their applications in machine learning.

2. Apply the perceptron update rule and understand convergence behavior.
3. Explore maximum margin classification and regularization techniques.
4. Learn kernel methods for non-linear classification and regression.
5. Understand probabilistic models.

COURSE OUTCOME:

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

CO-1:	Explain concepts of linear classification and regression.	K2
CO-2:	Implement non-linear prediction methods.	K3
CO-3:	Understand feature selection methods.	K2
CO-4:	Apply techniques for combining classifiers.	K3
CO-5:	Apply various clustering techniques.	K3
CO-6:	Understand the role of probabilistic approaches for various scenarios.	K2

COURSE CONTENT:

MODULE 1:	**LINEAR CLASSIFICATION AND REGRESSION**	**10 Hours**
Introduction, Linear Classification, Perceptron Update rule, Perceptron convergence, generalization, Maximum Margin classification, Classification errors, regularization, Logistic regression, linear regression.		
MODULE 2:	**ESTIMATION, KERNELS, AND MODEL SELECTION**	**10 Hours**
Estimator bias and variance, active learning, Non-linear prediction, kernels, kernel regression, Support vector machine (SVM) and kernels, kernel optimization, model selection, Model selection criteria.		
MODULE 3:	**FEATURE SELECTION, ENSEMBLE LEARNING, AND MIXTURE MODELS**	**10 Hours**
Description length, Feature Selection, Combining Classifiers, boosting, margin, and complexity, margin and generalization, mixture models, Mixture and expectation maximization (EM) algorithm, Regularization.		
MODULE 4:	**CLUSTERING AND PROBABILISTIC MODELS**	**8 Hours**
Clustering, Spectral Clustering, Markov Models, Hidden Markov Models(HMM), Bayesian Networks.		
MODULE 5:	**BAYESIAN NETWORKS AND COLLABORATIVE FILTERING**	**7 Hours**
Learning Bayesian Networks, Probabilistic inference, Collaborative filtering.		
TOTAL LECTURES		**45 Hours**

Text Books:

1. Pattern Classification. Richard, Duda, Peter Hart and David Stork, Wiley Interscience.
2. Machine Learning, Tom Mitchell, McGraw-Hill
3. Neural Networks for Pattern Recognition, C.M. Bishop, Oxford University Press

4. T Hastie, The Elements of Statistical Learning: Data Mining, Inference and prediction.
5. R.Tibshirani and J.H Friedman, NY. Springer, ISBN: 9780387952840

Program: M. Tech. in EE	**Year, Semester: 1st, 2nd**
Course Title: Power Electronics Application in EHV Transmission	**Subject Code:** TIU-PEE-T106
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

This course enables the students:

1. To understand the EHVAC and EHVDC transmission in contrast to common HVAC transmission
2. To be exposed to HVDC converters and its special control and protection schemes
3. To learn FACTS devices used along with overvoltage lines
4. To be exposed to harmonics problems associated with H.V.A.C and H.V.D.C transmissions

COURSE OUTCOME:

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

CO-1:	Understand the operation of HVDC transmission and HVDC converters.	K2
CO-2:	Understand the different protection schemes and control modes of HVDC links.	K2
CO-3:	Understand the operation and advantages of various FACTS devices	K3
CO-4:	Apply mathematical models of FACTS devices for simulation studies.	K4
CO-5:	Understand the sources of harmonics in power networks and methods for suppression.	K3
CO-6	Understand the dependency of power -flow on system parameters	K2

COURSE CONTENT:

MODULE 1:	**HVDC TRANSMISSION**	**15 hours**
HVDC Transmission: Converter operation, protection and control of HVDC link, modeling of HVDC system for power system studies.		
MODULE 2:	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**15 hours**
Flexible AC Transmission Systems: Series and shunt devices and principles of operation and control, UPFC and IPFC, modeling of FACTS devices for power system studies.		

MODULE 3:	HARMONICS IN POWER SYSTEM	12 hours
Harmonics in Power System: Sources of harmonics, study of harmonic penetration, Harmonics in HVDC converters, harmonic suppression.		
TOTAL LECTURES		42 hours

Reference Books:
1. Power System stability and control by P. Kundur Mc-Graw Hill
2. Understanding FACTS by Narain G. Hingorani
3. Flexible AC transmission systems by Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal.
4. FACTS Controllers In Power Transmission & Distribution by K. R. Padiyar
5. Power System Harmonic Analysis by Jos Arrillaga, Bruce C. Smith, Neville R. Watson, Alan R. Wood

Program: M. Tech. in EE	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Reliability Engineering	**Subject Code:** TIU-PEE-T108
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. Understand the concept and mathematical representation of reliability
2. Assess reliability of systems with different configuration using hazard models
3. Apply reliability concept on power and distribution networks

COURSE OUTCOME:

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

CO-1:	Define and differentiate key concepts of reliability, quality and failure.	K2
CO-2:	Apply probability concepts and continuous and discrete distributions to model and analyze reliability.	K3
CO-3:	Assess component reliability using hazard models.	K4
CO-4:	Evaluate reliability for series-parallel and non-series-parallel component dependencies of repairable and non-repairable systems.	K4
CO-5:	Apply concepts of reliability for Power network	K3
CO-6:	Assess reliability of substations of different configurations	K4

COURSE CONTENT:

Module 1	BASIC CONCEPTS OF RELIABILITY	15 Hours
Reliability, quality, failure: causes, modes, maintainability and availability. Redundancy techniques		

cost. Reliability Mathematics: Probability, continuous and discrete distributions.		
Module 2	**RELIABILITY ASSESSMENT**	**15 Hours**
Component reliability and hazard models, Markov's two state model. Systems with components in series and parallel. Non-series-parallel systems. Repairable systems, frequency of failures.		
Module 3	**RELIABILITY OF POWER AND DISTRIBUTION NETWORKS**	**14 Hours**
Static generation capacity reliability evaluation, deterministic risk model, loss of load expectation, Frequency and duration technique, substation failure events.		
TOTAL LECTURES		**44 Hours**

Text Books:

1. "Reliability Engineering", E. Balagurusamy
2. "Assessment of Power System Reliability: Methods and Applications", Marko Čepin.

Program: M. Tech. in EE	**Year, Semester:** 1stYear, 2nd Sem
Course Title: Overvoltage protection and Insulation coordination	**Subject Code:** TIU-PEE-T128
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit: 4**

COURSE OBJECTIVE:

This course enables the students:

1. To understand overvoltage transients in transmission lines
2. To learn the mechanism of lightning and protection against over-voltages
3. To learn the transients in Circuit Breaker operation
4. To be exposed to the principles of protection against over-voltages
5. To learn insulation coordination

COURSE OUTCOME:

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

CO-1:	Understand the types of transients and apply traveling wave phenomenon in transmission lines	K3
CO-2:	Understand the mechanism of lightning and power network over-voltages	K2
CO-3:	Understand the operation of Circuit Breaker	K2

CO-4:	Analyze the transients in circuit breaker operation	K4
CO-5:	Understand the principles of protection against over-voltages	K2
CO-6:	Understand the principles of Insulation Coordination	K2

COURSE CONTENT:

MODULE 1:	**Traveling Waves**	8 hours
Nature of Traveling Waves, Transmission line equation, attenuation, distortion, types of traveling waves, Reflection of traveling waves at a transition point, typical cases. Successive Reflections: Reflection lattice, lines with different terminations, line-cable connection, line-cable-transformer connection.		
MODULE 2:	**Lightning Phenomenon**	6 hours
Lightning: Mechanism of the lightning stroke, Mathematical model of lightning stroke. Over voltage due to lightning. Power frequency over voltages, over voltages due to faults. Switching over voltages, switching over-voltage reduction techniques.		
MODULE 3:	**High voltage AC circuit breakers**	8 hours
High voltage AC circuit breakers: Opposing forces during closing and opening operation, inter locks, indication and auxiliary switches, CB time, auto re-closure, transient recovery voltage, single frequency transient, double frequency transient, rate of rise of TRV, resistance switching, damping of TRV, opening resistors.		
MODULE 4:	**Protection of power system against over voltages**	10 hours
Protection of power system against over voltages: General principles of lighting protection, ground wires, surge arresters, counter poises, tower footing resistances, protection of rotating machines against surges.		
MODULE 5:	**Insulation coordination**	10 hours
Insulation characteristics of long air gaps: Types of electrode geometries, breakdown characteristics of long air gaps, breakdown models of long gaps with non-uniform fields, CFO and withstand voltages of long air gaps. Insulation Coordination: Protective characteristics of rod gaps, surge arrestors, insulation withstand voltage characteristics, correlation between insulation and protective levels, and illustration of insulation coordination in an EHV substation.		

TOTAL LECTURES	**42 Hours**

Reference Books:
1. Traveling waves of Transmission systems – by LV Bewley.
2. Insulation Coordination ELBS in H.V. Electrical Power Systems by W.Diesendorf, Butter worth publications, London, 1974.
3. E.H.V. Transmission Engineering: Rakosh Das Begamudre, Wiley Eastern Ltd., New Delhi, 1986.

Program: M. Tech. in EE	**Year, Semester:** 1st Year, 2nd Sem.
Course Title: Power System Operation and Control	**Subject Code:** TIU-PEE-T130
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. To understand the characteristics of power generation and frequency control in interconnected power systems.
2. To analyze load frequency control (LFC) and automatic generation control (AGC) for stable power system operation.
3. To study economic dispatch and unit commitment methods to optimize power generation costs.
4. To explore hydrothermal coordination techniques for efficient scheduling of hydro and thermal power plants.
5. To understand power interchange mechanisms such as energy banking, emergency power exchange, and power pools.
6. To learn about deregulation and wheeling in modern power systems for better energy market operations.

COURSE OUTCOME:

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

CO-1:	Understanding Generation and Frequency Characteristics in Power Systems.	K1
CO-2:	Analyzing Load Frequency Control and Automatic Generation Control (AGC).	K4
CO-3:	Applying Economic Dispatch and Unit Commitment Methods.	K3
CO-4:	Evaluating Hydrothermal Coordination for Power Generation.	K4

CO-5:	Understanding Power Interchange and Energy Banking among Utilities.	K2
CO-6:	Exploring Power Pools, Wheeling, and Deregulation in Power Systems.	K2

COURSE CONTENT:

MODULE 1:		**13 Hours**
Generation/Frequency Characteristics and load frequency characteristics, tie-line bias control, Automatic Generation Control, Alert and emergency system operation control. Control of reactive power flow.		
MODULE 2:		**15 Hours**
Economic dispatch: The lambda iteration method, newton's method. Unit commitment: Dynamic programming. Hydrothermal co-ordination: Long-term and short-term.		
MODULE 3:		**15 Hours**
Interchange of Power and energy: economy interchange between interconnected utilities, inter-utility economy energy evaluation, Capacity interchange, diversity interchange, energy banking, Emergency Power Interchange, Power pools, Wheeling, Deregulation.		
Total:		43 Hours

Books:

1. Power generation, operation, and control, Allen J. Wood, Bruce F, Wollenberg

Program: M. Tech. in EE	**Year, Semester:** 1st Yr. 2nd Sem.
Course Title: Term Paper Leading to Thesis	**Subject Code:** TIU-PEE-L124
Contact Hours/Week: 0–0–3 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE:

Enable the student to:

1. To equip students with the ability to identify and define relevant research problems.
2. To enable students to conduct comprehensive literature reviews and identify research gaps.
3. To develop the necessary skills to adapt to new research methodologies and acquire relevant knowledge.

COURSE OUTCOME:

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

CO-1:	Identify relevant research problems.	K1

CO-2:	Conduct comprehensive literature surveys regarding a specific research topic.	K2
CO-3:	Identify research gaps in the studied literature.	K3
CO-4:	Demonstrate the ability to adapt and acquire new knowledge and skills relevant to their research topic.	K4
CO-5	Create a report based on analyzed research data.	K4
CO-6	Draw meaningful conclusions and suggest potential avenues for future investigation.	K4

COURSE CONTENT:

MODULE 1:	**Introduction to Research & Problem Identification**	**8 Hours**
Introduction to Research - Identifying a Research Problem		
MODULE 2:	**Literature Review and Citation Management**	**6 Hours**
Conducting a Literature Review - Citation Tools and Referencing		
MODULE 3:	**Identifying Research Gaps**	**8 Hours**
Evaluating Literature for Research Gaps - Framing Research Questions Based on Gaps		
MODULE 4:	**Research Methodology and Data Collection**	**8 Hours**
Research Methodologies: Qualitative & Quantitative - Data Collection and Interpretation		
MODULE 5:	**Academic Writing and Ethical Considerations**	**8 Hours**
Academic Writing Styles - Ethical Issues in Research		
MODULE 6:	**Presenting Research & Future Scope**	**6 Hours**
Structuring Research Papers - Presenting Research & Future Research Directions		
TOTAL LECTURES		**44 Hours**

Program: M. Tech. in EE	**Year, Semester:** 1st Yr. 2nd Sem.
Course Title: Seminar	**Subject Code:** TIU-PEE-S102
Contact Hours/Week: 0–0–3 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE:

Enable the student to:

1. To enable students to thoroughly explore and review scholarly literature on advanced topics.

2. To cultivate students' abilities in critical analysis and logical reasoning to assess current research and pinpoint areas lacking investigation.
3. To strengthen students' skills in articulating and presenting technical information clearly and confidently.

COURSE OUTCOME:

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

CO-1:	Perform detailed reviews of scholarly work related to a particular research area	K1
CO-2:	Critically assess and interpret the existing body of literature on the subject.	K2
CO-3:	Enhance abilities in presenting and explaining concepts effectively.	K3
CO-4:	Recognize unresolved issues or unexplored areas within the reviewed literature.	K3
CO-5:	Create a well-organized seminar based on analyzed research data.	K4
CO-6:	Draw meaningful conclusions and suggest potential avenues for future investigation.	K4

COURSE CONTENT:

MODULE 1:	**Introduction to Research**	**9 Hours**
Exploration of various research strategies – Significance of conducting literature reviews – Locating and utilizing major sources of academic information.		
MODULE 2:	**Literature Survey and Data Collection**	**6 Hours**
Techniques for efficient information retrieval – Assessing the credibility of research – Systematic organization of collected data.		
MODULE 3:	**Critical Analysis of Research Papers**	**9 Hours**
Examining different research methods – Detecting limitations and unaddressed areas in existing studies – Evaluating and contrasting diverse research methodologies.		
MODULE 4:	**Presentation Techniques and Communication Skills**	**6 Hours**
Planning and delivering technical presentations – Using clear and effective communication tools – Engaging with the audience and addressing their queries.		
MODULE 5:	**Research Gap Analysis and Future Scope**	**6 Hours**
Discovering potential research opportunities – Developing research questions or hypotheses – Drawing conclusions and outlining future work.		
MODULE 6:	**Seminar and Report Writing**	**6 Hours**
Developing a structured and well-formatted research report – Applying proper referencing styles – Getting ready for final seminar presentation.		
TOTAL LECTURES		**42 Hours**

Second Year: Third Semester

Subject Code	Subject	Contacts			Credits
		L	T	P	
TIU-PEE-P299	Thesis Work	0	0	6	3
TIU-PEE-G299	Viva-Voce on Thesis	0	0	6	3
Total					**6**

Program: M. Tech. in EE	**Year, Semester:** 2nd Yr. 3rd Sem.
Course Title: Thesis Work	**Subject Code:** TIU-PEE-P299

Contact Hours/Week: 0-0-6 (L-T-P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. To equip students with the necessary skills to conduct a detailed literature review and formulate research problems.
2. To Enable students to develop technical writing and presentation skills for effective communication of research findings through synopsis preparation, conference publications, and journal papers.
3. To guide students in identifying research gaps, developing experimental methodologies, and contributing to scholarly publications.

COURSE OUTCOME:

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

CO-1:	Understand the fundamentals of research methodologies and literature review techniques.	K1
CO-2:	Analyze and evaluate research literature to identify gaps and formulate research problems.	K2
CO-3:	Develop skills in technical writing, synopsis preparation, and structuring conference/journal papers.	K3
CO-4:	Design and implement research methodologies, including data collection and experimentation.	K3
CO-5:	Synthesize research findings into a well-structured thesis document and technical paper for publication.	K4
CO-6:	Critically review and refine research work based on peer feedback, preparing for high-quality academic publications.	K4

COURSE CONTENT:

Module 1	**Introduction to Research and Thesis Writing**	
Overview of research - Importance of literature review and problem identification - Research ethics and plagiarism		
Module 2	**Literature Review and Research Gap Identification**	
Techniques for literature search and reference management - Evaluating research papers for quality and relevance - Identifying research gaps and defining objectives		
Module 3	**Research Methodologies and Experimental Design**	
Types of research methodologies (qualitative, quantitative, experimental) - Data collection, measurement techniques, and instrumentation - Simulation and modeling tools in electrical engineering		

Module 4	**Synopsis and Technical Paper Writing**	
Structuring a research synopsis - Writing technical papers for conferences and journals - Formatting guidelines (IEEE, Elsevier, Springer, etc.)		
Module 5	**Presentation Skills and Peer Review**	
Structuring and delivering effective research presentations - Handling Q&A and responding to peer reviews - Preparing for conferences and thesis defense		
Module 6	**Thesis Compilation and Final Submission**	
Structuring the thesis document (abstract, introduction, methodology, results, conclusion) - Citation and referencing techniques - Submission guidelines and publication strategies		
Module 7	**Progress Evaluation and Interim Review**	
Conduct internal evaluations through seminars to assess literature review, problem identification, and research objectives.		
Module 8	**Final Thesis Presentation and Viva Preparation**	
Includes mock viva sessions, Q&A simulations, refining thesis based on feedback, and final presentation rehearsals.		

Program: M. Tech. in EE	**Year, Semester:** 2nd Yr. 3rd Sem.
Course Title: Viva-Voce on Thesis	**Subject Code:** TIU-PEE-G299
Contact Hours/Week: 0-0-6 (L-T-P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. To prepare students to effectively present and defend their research work during viva voce examinations.
2. To develop critical thinking and technical articulation skills to answer questions on methodology, dataset, results, drawbacks, and contributions of the research.
3. To Equip students with the ability to handle peer and expert feedback, refine their thesis, and identify future research directions.

COURSE OUTCOME:

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

CO-1:	Understand the fundamental structure and evaluation criteria of thesis viva voce.	K1
CO-2:	Analyze research methodologies, datasets, and results to justify the research	K2

	approach.	
CO-3:	Explain and defend research findings, identifying drawbacks in existing research.	K3
CO-4:	Compare different methodologies and articulate the advantages of the proposed approach.	K3
CO-5:	Address examiner queries, discuss publication contributions, and critically assess research impact.	K4
CO-6:	Demonstrate research originality and propose future scope based on viva voce feedback.	K4

COURSE CONTENT:

Module 1	**Introduction to Thesis Viva Voce**	
Purpose and significance of viva voce - Structure and format of thesis defense - Common types of viva voce questions		
Module 2	**Research Methodology and Dataset Justification**	
Selection of research methodology (experimental, simulation, analytical) - Justifying dataset choice and preprocessing techniques - Addressing limitations and assumptions in data analysis		
Module 3	**Research Contribution and Existing Work Comparison**	
Identifying drawbacks in existing research - Highlighting key contributions and originality of the work - Defending research novelty with supporting evidence		
Module 4	**Discussion on Results and Performance Analysis**	
Presenting experimental/simulation results effectively - Statistical validation and performance comparison - Answering critical questions on research accuracy and reliability		
Module 5	**Publication and Research Impact**	
Overview of conference and journal publications - Addressing publication-related questions in viva -Discussing citations, indexing, and research impact factors		
Module 6	**Future Scope and Research Extension**	
Identifying potential future research directions - Suggestions for improvement and further experimentation - Handling examiner recommendations and modifications		
Module 7	**Mid-Semester Viva (Viva-1)**	
Assesses student knowledge on literature review, problem statement, methodology, and dataset. Identifies research gaps and evaluates progress.		
Module 8	**Final Viva-Voce Defense (Viva-2)**	

Students defend full thesis work including results, contributions, publications, and future work. Final evaluation includes thesis and oral performance.

Second Year: Fourth Semester

Subject Code	Subject	Contacts			Credits
		L	T	P	
TIU-PEE-P298	Thesis Work	0	0	6	3
TIU-PEE-G298	Viva-Voce on Thesis	0	0	6	3
Total					**6**

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Program: M. Tech. in EE	**Year, Semester:** 2nd Yr. 4th Sem.
Course Title: Thesis Work	**Subject Code:** TIU-PEE-P298
Contact Hours/Week: 0-0-6 (L-T-P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. To equip students with the necessary skills to conduct a detailed literature review and formulate research problems.
2. To Enable students to develop technical writing and presentation skills for effective communication of research findings through synopsis preparation, conference publications, and journal papers.
3. To guide students in identifying research gaps, developing experimental methodologies, and contributing to scholarly publications.

COURSE OUTCOME:

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

CO-1:	Understand the fundamentals of research methodologies and literature review techniques.	K1
CO-2:	Analyze and evaluate research literature to identify gaps and formulate research problems.	K2
CO-3:	Develop skills in technical writing, synopsis preparation, and structuring conference/journal papers.	K3
CO-4:	Design and implement research methodologies, including data collection and experimentation.	K3
CO-5:	Synthesize research findings into a well-structured thesis document and technical paper for publication.	K4
CO-6:	Critically review and refine research work based on peer feedback, preparing for high-quality academic publications.	K4

COURSE CONTENT:

Module 1	**Introduction to Research and Thesis Writing**	
Overview of research - Importance of literature review and problem identification - Research ethics and plagiarism		
Module 2	**Literature Review and Research Gap Identification**	
Techniques for literature search and reference management - Evaluating research papers for quality and relevance - Identifying research gaps and defining objectives		
Module 3	**Research Methodologies and Experimental Design**	

Types of research methodologies (qualitative, quantitative, experimental) - Data collection, measurement techniques, and instrumentation - Simulation and modeling tools in electrical engineering		
Module 4	**Synopsis and Technical Paper Writing**	
Structuring a research synopsis - Writing technical papers for conferences and journals - Formatting guidelines (IEEE, Elsevier, Springer, etc.)		
Module 5	**Presentation Skills and Peer Review**	
Structuring and delivering effective research presentations - Handling Q&A and responding to peer reviews - Preparing for conferences and thesis defense		
Module 6	**Thesis Compilation and Final Submission**	
Structuring the thesis document (abstract, introduction, methodology, results, conclusion) - Citation and referencing techniques - Submission guidelines and publication strategies		
Module 7	**Progress Evaluation and Interim Review**	
Conduct internal evaluations through seminars to assess literature review, problem identification, and research objectives.		
Module 8	**Final Thesis Presentation and Viva Preparation**	
Includes mock viva sessions, Q&A simulations, refining thesis based on feedback, and final presentation rehearsals.		

Program: M. Tech. in EE	**Year, Semester:** 2nd Yr. 4th Sem.
Course Title: Viva-Voce on Thesis	**Subject Code:** TIU-PEE-G298
Contact Hours/Week: 0-0-6 (L-T-P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. To train students in confidently presenting and justifying their research during viva voce sessions.
2. To enhance students' analytical thinking and ability to clearly explain aspects like research methods, data usage, findings, limitations, and overall contributions.
3. To build the capability to respond to feedback from peers and examiners, make necessary improvements to their thesis, and explore possible future research paths..

COURSE OUTCOME:

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

CO-1:	Grasp the basic framework and assessment standards used in thesis viva examinations.	K1
CO-2:	Evaluate research strategies, data selection, and outcomes to support and validate the chosen research path.	K2
CO-3:	Present and justify research conclusions while recognizing limitations in related existing studies.	K3
CO-4:	Contrast various research methods and effectively communicate the strengths of the chosen technique.	K3
CO-5:	Respond to examiner questions, highlight publication outcomes, and thoughtfully evaluate the significance of the research.	K4
CO-6:	Showcase originality in the research work and outline potential directions for future studies based on feedback from the viva.	K4

COURSE CONTENT:

Module 1	**Introduction to Thesis Viva Voce**	
Purpose and significance of viva voce - Structure and format of thesis defense - Common types of viva voce questions		
Module 2	**Research Methodology and Dataset Justification**	
Selection of research methodology (experimental, simulation, analytical) - Justifying dataset choice and preprocessing techniques - Addressing limitations and assumptions in data analysis		
Module 3	**Research Contribution and Existing Work Comparison**	
Identifying drawbacks in existing research - Highlighting key contributions and originality of the work - Defending research novelty with supporting evidence		
Module 4	**Discussion on Results and Performance Analysis**	
Presenting experimental/simulation results effectively - Statistical validation and performance comparison - Answering critical questions on research accuracy and reliability		
Module 5	**Publication and Research Impact**	
Overview of conference and journal publications - Addressing publication-related questions in viva -Discussing citations, indexing, and research impact factors		
Module 6	**Future Scope and Research Extension**	
Identifying potential future research directions - Suggestions for improvement and further experimentation - Handling examiner recommendations and modifications		

Module 7	**Mid-Semester Viva (Viva-1)**	
Assesses student knowledge on literature review, problem statement, methodology, and dataset. Identifies research gaps and evaluates progress.		
Module 8	**Final Viva-Voce Defense (Viva-2)**	
Students defend full thesis work including results, contributions, publications, and future work. Final evaluation includes thesis and oral performance.		