

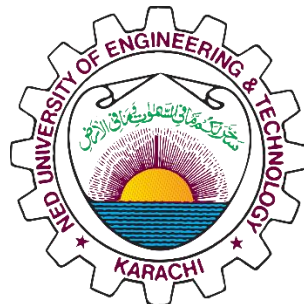
COURSE SYLLABUS

POST GRADUATE MASTERS OF ENGINEERING PROGRAMME

DEPARTMENT OF ELECTRICAL ENGINEERING

SPECIALIZATIONS:

- **ELECTRICAL POWER SYSTEM**
- **ELECTRICAL MACHINES**
- **CONTROL SYSTEM**
- **ENERGY MANAGEMENT**
- **SMART GRID**



NED UNIVERSITY OF ENGINEERING & TECHNOLOGY

MASTERS OF ENGINEERING (ELECTRICAL POWER SYSTEM)

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MASTERS OF ENGINEERING (ELECTRICAL POWER SYSTEMS)

List of Courses for the M.Engg. Programme in Electrical Engineering

Table 1 Electrical Power Systems (Compulsory Courses)

Course No.	Course Title	Credit Hrs
EE-521	Power System Analysis -1	3
EE-522	Power System Analysis - II	3
EE-523	Power System Protection	3
EE-524	Electrical Power Distribution System Engg.-I System Engg.-I	3
EE-526	Electrical Power Transmission System Engineering	3

Table 2 Electrical Power Systems (Elective Courses)

Course No.	Course Title	Credit Hrs
EE-525	Electrical Power Distribution System Engg.-II	3
EE-527	Power System Stability	3
EE-528	Computer Methods in Power System Analysis	3
EE-529	Power System Reliability	3
EE-530	Power System Protection using Static Relays	3
EE-531	Embedded Power Generation	3
EE-532	Reactive Power Control	3
EE-501	Linear Control Systems	3
EE-505	Digital Control System	3
EE-512	Advanced Digital Signal Processing	3
EE-543	Solid State DC Drives	3
EE-544	Solid State AC Drives	3
EE-5002	Thesis	6

Detailed Contents of Courses for the M. Engg. Programme in Electrical Engineering (Electrical Power Systems)

Compulsory Courses

EE-521 Power System Analysis-I

Load flow studies, System formulation and modeling techniques of solutions, Voltage profile and control. System optimisation, operation and commitments, Optimum scheduling. Optimisation of combination of Hydro-Thermal systems, automatic generation and voltage control, load frequency control, valve model, turbine model, block diagrams and the control model, single and two area load frequency control.

EE-522 Power System Analysis-II

Symmetrical Components, Unsymmetrical shunt and faults, sequence impedance of transmission lines, machines and transformers, change of symmetry, simultaneous faults, two component method for fault analysis.

EE-523 Power System Protection

Protective relaying philosophy and fundamental considerations, transmission lines, rotating machines and transformer protection, Relay input sources and their performance. Static relays. Basic components of static relays, Comparator, Basic static relays used in protective schemes.

EE-524 Electrical Power Distribution System Engineering-I

Distribution System Planning and Automation, Load Characteristics, Application of Distribution transformation, Design of Sub-transmission lines and distribution substations, Design considerations of primary system. Design considerations of secondary systems, Voltage-Drop and Power loss calculations.

EE-526 Electrical Power Transmission System Engineering

Intense and rigorous treatment of the constants of HV and EHV lines and cables, Mathematical modeling, Insulation coordination and their effects on insulation during short circuits, Travelling waves, Optimum loading of facilities, effects of line transients on insulation. HV DC transmission, Type of DC links, technical and economic advantages of DC transmission, Incorporation of HV DC into AC systems, Converter station equipment, skin effects.

Elective Courses

EE-525 Electrical Power Distribution System Engineering-II

Application of capacitors to distribution system, Distribution system voltage regulation. Distribution system protection, Distribution system reliability.

EE-527 Power System Stability

Steady state and transient stability problems of multi-machine interconnected systems, Swing equation, point-by-point solution of swing equation. Equal area criterion, One machine and two-machine systems, Critical fault clearing time. Effect of fault on stability, Stability study of typical systems.

EE-528 Computer Methods in Power System Analysis

Network Matrices, Algorithms for formation of network matrices, short circuit studies, solution of simultaneous algebraic equations, Load flow studies, Numerical solution of differential equations, transient stability studies.

EE-529 Power System Reliability

Network and state space methods for reliability evaluation. Component reliability, Generating capacity reserve evaluation and operating reserve evaluation. Interconnected systems, Bulk power system reliability. Area supply reliability, distribution systems reliability, reliability modeling.

EE-530 Power System Protection using Static Relays

Static Relays, comparators, components, circuits and power supply circuit for static relays, Time relays. Voltage relays, directional, over current, differential and distance relays, pilot wire and carrier current schemes.

EE-531 Embedded Power Generation

Reasons, extent, issues and technical impacts of embedded or dispersed generation. Economic impacts of embedded generation on transmission, distribution and central generation systems. Embedded generation plants, combined heat and power plants, renewable energy generation- small scale hydro-generation, wind power plants, off-shore wind energy, solar photovoltaic generation. Power flow studies of an embedded generation scheme, balanced and unbalanced fault studies as applied to an embedded generation scheme. Stability studies of an embedded generation scheme, electromagnetic transient studies, and generators for embedded generation, power quality and protection of embedded generation.

EE-532 Reactive Power Control

Definition of terms used in Reactive Power Management. Quality in electrical power supply. Indices and cost of power quality, justification for capital cost, costing of reactive power. Reactive power requirement of utilities. Reactive power supply by utilities. Systems and tools for management of reactive power by utilities. User-side scenario of reactive power management, compensation, planning, selection of equipments, consideration of harmonics. Reactive power management in different types of industrial plants.

EE-501 Linear Control Systems

Properties of feedback control systems, Mathematical models of basic components, State-variable models of feedback systems, time-domain analysis, stability, transform analysis, frequency domain techniques, root-locus, design of single input-output systems, simple compensation techniques.

EE-505 Digital Control Systems

Examples of Discrete Data and Digital Control Systems, Signal Conversion and Processing, Sampling theorem, z-transform and inverse z-transform. The state-variable approach. Stability of Digital control system. Digital Simulation and digital redesign.

EE-512 Advanced Digital Signal Processing

Review of discrete signals and systems in temporal and spectral domains, data acquisition, discrete transforms (DFT, DCT and z-transforms), digital filters—HR and FIR, spectral estimation, adaptive filters, multi-rate signal processing, Wavelets and joint time-frequency analysis, and real-time signal processing.

EE-543 Solid State DC Drives

Variable speed drive systems, Separately excited and series dc motor single phase drives, Power factor improvement. Three phase drives. Semi converter, Full converter series connected and dual converter drives. Reversible drives. DC Chopper Drives. Dynamic and regenerative braking. Closed loop control. Phase Locked Loop control and Microprocessor control.

EE-544 Solid State AC Drives

Review of three phase induction motor speed control, Speed control by Slip-Energy Recovery schemes, Induction motor with voltage source inverters, Induction motor with current source inverters, Synchronous motor drives. Stepper motor drives. Cyclo-converter controlled AC drives. Brushless synchronous machines.

MASTERS OF ENGINEERING (ELECTRCIAL MACHINES)

MASTERS OF ENGINEERING (ELECTRICAL MACHINES)

List of Courses for the M.Engg. Programme in Electrical Engineering

Table 3 Electrical Machines (Compulsory Courses)

Course No.	Course Title	Credit Hrs
EE-541	Power Electronics- I	3
EE-542	Power Electronics - II	3
EE-543	Solid State DC Drives	3
EE-544	Solid State AC Drives	3
EE-545	Electrical Machines Design	3

Table 4 Electrical Machines (Elective Courses)

Course No.	Course Title	Credit Hrs
EE-546	Special Electrical Machines	3
EE-547	Unified Theory of Electrical Machines	3
EE-548	Elements of Machine Control	3
EE-549	Electrical Machines Protection System	3
EE-501	Linear Control Systems	3
EE-505	Digital Control System	3
EE-524	Electrical Power Distribution System Engg.-I	3
EE-525	Electrical Power Distribution System Engg.-II	3
EE-526	Electrical Power Transmission System Engineering	3
EE-5002	Thesis	6

Detailed Contents of Courses for the M. Engg. Programme in Electrical
(Machines Engineering)

Compulsory Courses

EE-541 Power Electronics-I

Solid-state power devices, single phase & three phase controlled rectifiers. Driving the transistor and its protection, Driving the Thyristor and its protection. Power factor improvement of thyristor controlled load, DC-to-DC Switch Mode Converters. Switching DC Power Supplies. Power conditioners and Un-interruptible Power Supplies. Thyristor Forced Commutated DC Choppers.

EE-542 Power Electronics-II

Single phase and three phase AC voltage controllers. Single phase and three phase Cycloconverters. Thyristor commutation techniques. Single phase and three phase inverters. Modulation techniques. DC link and hidden link inverters. Resonant pulse converters. Zero voltage and zero current converters.

EE-543 Solid State DC Drives

Variable speed drive systems, Separately excited and series dc motor single phase drives, Power factor improvement. Three phase drives. Semi converter, Full converter series connected and dual converter drives. Reversible drives. DC Chopper Drives. Dynamic and regenerative braking. Closed loop control. Phase Locked Loop control and Microprocessor control.

EE-544 Solid State AC Drives

Review of three phase induction motor speed control, Speed control by Slip-Energy Recovery schemes, Induction motor with voltage source inverters, Induction motor with current source inverters, Synchronous motor drives. Stepper motor drives. Cyclo-converter controlled AC drives. Brushless synchronous machines.

EE-545 Electrical Machines Design

Design of transformers, DC machines, Single phase and three phase induction motors, Design of synchronous machines.

Elective Courses

EE-546 Special Electrical Machines

Linear Induction motors, linear synchronous motors, Reluctance motors, Numerically Controlled stepper motors.

EE-547 Unified Theory of Electrical Machines

Matrix equation, Matrix Analysis of transformer, general unified theory of rotating machines, Application of the general theory in the analysis of DC machines, 1-phase and 3-phase induction motors.

EE-548 Elements of Machine Control

Parameters of machines to be controlled. Types of Controls, Powers Switches, Temperature Control of Power Switches, Drivers, Voltage Regulators, Passive devices used in machine control.

EE-549 Electrical Machine Protection System

Protection & Measurement Devices, Transformer and Reactor Protection, Transformer Faults, Magnetising Inrush, Protection Against incipient Faults. Protection Against Active Faults, Regulating Transformer Protection, Shunt Reactor Protection. Generator Protection, Type, Stator & Rotor Protection, Loss of Excitation Protection, Other Protection. Motor Protection, Motor Problems, Stator & Rotor Protection, Other Protection.

EE-501 Linear Control Systems

Properties of feedback control systems, Mathematical models of basic components, State-variable models of feedback systems, time-domain analysis, stability, transform analysis, frequency domain techniques, root-locus, design of single input-output systems, simple compensation techniques.

EE-505 Digital Control Systems

Examples of Discrete Data and Digital Control Systems, Signal Conversion and Processing, Sampling theorem, z-transform and inverse z-transform. The state-variable approach. Stability of Digital control system. Digital Simulation and digital redesign

EE-524 Electrical Power Distribution System Engineering-I

Distribution System Planning and Automation, Load Characteristics, Application of Distribution transformation, Design of Sub-transmission lines and distribution substations, Design considerations of primary system. Design considerations of secondary systems, Voltage-Drop and Power loss calculations

EE-525 Electrical Power Distribution System Engineering-II

Application of capacitors to distribution system, Distribution system voltage regulation. Distribution system protection, Distribution system reliability.

EE-526 Electrical Power Transmission System Engineering

Intense and rigorous treatment of the constants of HV and EHV lines and cables, Mathematical modeling, Insulation coordination and their effects on insulation during short circuits, Travelling waves, Optimum loading of facilities, effects of line transients on insulation. HV DC transmission, Type of DC links, technical and economic advantages of DC transmission, Incorporation of HV DC into AC systems, Converter station equipment, skin effects.

MASTERS OF ENGINEERING (CONTROL SYSTEM)

MASTERS OF ENGINEERING (CONTROL SYSTEMS)

List of Courses for the M.Engg. Programme in Electrical Engineering

Table 5 Control Systems (Compulsory Courses)

Course No.	Course Title	Credit Hrs
EE-501	Linear Control Systems	3
EE-502	Optimal Control Systems	3
EE-503	Random Variables & Stochastic Processes	3
EE-504	Adaptive Control Systems	3
EE-505	Digital Control System	3

Table 6 Control Systems (Elective Courses)

Course No.	Course Title	Credit Hrs
EE-506	Linear Multivariable Control Theory	3
EE-507	Non Linear Control Systems	3
EE-508	Stochastic Processes in Electrical Engineering	3
EE-509	Estimation Theory	3
EE-510	Stochastic Control Systems	3
EE-511	Graph Theory	3
EE-512	Advanced Digital Signal Processing	3
EE-524	Electrical Power Distribution System Engg.-I	3
EE-525	Electrical Power Distribution System Engg.-II	3
EE-526	Electrical Power Transmission System Engineering	3
EE-529	Power System Reliability	3
EE-5002	Thesis	6

Detailed Contents of Courses for the M. Engg. Programme in Electrical (Control Systems)

Compulsory Courses

EE-501 Linear Control Systems

Properties of feedback control systems, Mathematical models of basic components, State-variable models of feedback systems, time-domain analysis, stability, transform analysis, frequency domain techniques, root-locus, design of single input-output systems, simple compensation techniques.

EE-502 Optimal Control Systems

Analysis, design and optimisation of analog and digital control systems, concepts of controllability and observability, specification of optimum performance indices. Utilisation of constraints in fixed configuration compensator design system parameter identification from measured data. Adaptive and optimal control problems. Computer techniques in design and optimisation.

EE-503 Random variables and Stochastic Process

Probability and random variables, characteristic functions, transformation of random variables, sequences of random variables, linear mean squared estimation, stationary estimation, stationary random process, correlation functions, power spectrum output of linear systems with stochastic input, Gaussian process.

EE-504 Adaptive Control Systems

Identification of adaptive control systems, mathematical modeling of the systems based on measurement data that may be limited or uncertain. Adaptive control of mathematically modeled systems. Various approaches including least square method of identification, analysis, design and stability study of adaptive control systems.

EE-505 Digital Control Systems

Examples of Discrete Data and Digital Control Systems, Signal Conversion and Processing, Sampling theorem, z-transform and inverse z-transform. The state-variable approach. Stability of Digital control system. Digital Simulation and digital redesign.

Elective Courses

EE-506 Linear Multivariable Control Theory

Algebraic theory of multivariable feedback, Static and dynamic decoupling, Invertibility, Model control, Integrity, Computer aided frequency domain design techniques using inverse Nyquist arrays and characteristic logic design.

EE-507 Non Linear Control Systems

Identification of Linear and non Linear Systems, approximate analysis of non linear systems, describing functions, Krylov and Bogoliubov's asymptotical method and Tsypkin's locus. Forced oscillation, jump response, stability analysis, Liapunov's criterion, Lure's problem and Popes method.

EE-508 Stochastic Processes in Electrical Engineering

Markov Chains, state classification, kolmogorov equations, applications to Probabilistic finite state machines, Birth-death process, applications to queing theory, buffer problems and the design of communication nets. Continuous state processes, diffusing processes, passage time and estimation problems, estimation and power spectra. Stochastic difference and differential equation.

EE-509 Estimation Theory

Optimal estimation theory including linear and nonlinear estimation of discrete and continuous random functions. Wiener and Kalman filter theory.

EE-510 Stochastic Control Systems

Introduction to random processes, properties of Markov processes, systems of covariance, deterministic and stochastic control equivalence, dynamic programming for Markov processes, principle of optimality, Kalman filtering, smoothing and preciting. The separation theorem and applications, concepts of adaptive estimations.

EE-511 Graph Theory

An introduction to oriented and non-oriented graphs, circuit concepts of linear vector space, network analysis and synthesis, topological formulae, the theory of switching, logic network paths, reachability, connectedness, tree representations, transportation flows, communication and manipulation of computer data, PERT and other related techniques.

EE-512 Advanced Digital Signal Processing

Review of discrete signals and systems in temporal and spectral domains, data acquisition, discrete transforms (DFT, DCT and z-transforms), digital filters—HR and FIR, spectral estimation, adaptive filters, multi-rate signal processing, Wavelets and joint time-frequency analysis, and real-time signal processing.

EE-524 Electrical Power Distribution System Engineering-I

Distribution System Planning and Automation, Load Characteristics, Application of Distribution transformation, Design of Sub-transmission lines and distribution substations, Design considerations of primary system. Design considerations of secondary systems, Voltage-Drop and Power loss calculations.

EE-525 Electrical Power Distribution System Engineering-II

Application of capacitors to distribution system, Distribution system voltage regulation. Distribution system protection, Distribution system reliability.

EE-526 Electrical Power Transmission System Engineering

Intense and rigorous treatment of the constants of HV and EHV lines and cables, Mathematical modeling, Insulation coordination and their effects on insulation during short circuits, Travelling waves, Optimum loading of facilities, effects of line transients on insulation. HV DC transmission, Type of DC links, technical and economic advantages of DC transmission, Incorporation of HV DC into AC systems, Converter station equipment, skin effects.

EE-529 Power System Reliability

Network and state space methods for reliability evaluation. Component reliability, Generating capacity reserve evaluation and operating reserve evaluation. Interconnected systems, Bulk power system reliability. Area supply reliability, distribution systems reliability, reliability modeling.

MASTERS OF ENGINEERING (ENERGY MANAGEMENT)

MASTERS OF ENGINEERING (ENGINEERING MANAGEMENT)

List of Courses for the Master of Engineering Management Programme

Table 7 Energy Management (Compulsory Courses)

Course No.	Course Title	Credit Hrs.
EM-501	Organisational Systems	3
EM-502	Accounting and Financial Management	3
EM-503	Strategic Planning and Decision Making	3
EM-505	Project Management Framework and Tools	3
EM-504	Operations Research	3

Table 8 Energy Management (Common Electives)

Course No.	Course Title	Credit Hrs.
EM-511	Total Quality Management	3
EM-512	Project Evaluation and Feasibility Analysis	3
EM-513	Research Methods in Engineering Management	3

Table 9 Energy Management (Elective Courses)

Course No.	Course Title	Credit Hrs.
EE-561	Power Generation Economics	3
EE-562	Energy Audits	3
EE-563	Energy Conservation	3
EE-564	Power System Restructuring	3
EE-565	Distributed Generation	3
EE-566	Reliability Engineering	3
EE-567	Energy Planning	3
EE-568	Reactive Power Management	3
EE-5002	Thesis	6

Detailed Contents of Courses for the Master of Engineering Management Programme

Compulsory Courses

EM-501 Organisational Systems

Definitions of management; Evolution of management thought, classical, quantitative and behavioral schools; interactions between organisations and their environments. The planning process; strategic and tactical planning, developing planning premises, nature of managerial decision making, quantitative aids, management by objectives. Organisational structures; behavior of the individual, work group, and organisation; coordination and spans of control, the informal organisation; authority delegation and decentralisation, groups and committees, managing organisational change and conflict. Motivation, performance and satisfaction; building a high-performance team; leadership, interpersonal and organisational communication, staffing and personal function. The control process; budgetary and non-budgetary methods of control; team performance measurement and improvement strategies. Use of management information systems.

EM-502 Accounting and Financial Management

Foundations of finance with applications in corporate finance and investment management. Major financial decisions made by corporate managers and investors with focus on process valuation. Criteria for investment decisions, valuation of financial assets and liabilities, relationships between risks and return, market efficiency, and the valuation of derivative securities. Major corporate financial instruments including debt, equity and convertible securities. Analysis and projection of financial statements, cost elements in pricing, cost control and design of accounting systems.

EM-503 Strategic Planning and Decision Making

Critical issues in shaping the competitive strategy for engineering-driven companies in a turbulent business environment; corporate mission; key result areas and situational analysis including strengths, weaknesses, opportunities and threats; identifying planning assumptions, critical issues, setting objectives, formulating strategy. Managing technology as a strategic resource of the firm; understanding of the process, roles and rewards of technological innovation; integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering and manufacturing; government, societal and international issues; issues pertaining to cultural diversity and ethical concerns. Subjective, judgmental and expert decisions; conflict resolution in strategic decisions involving technological alternatives; hierarchical decision modeling; individual and aggregate decisions; decision discrepancies and evaluation of group disagreements.

EM-504 Project Management Framework and Tools

Role of projects in organisation's competitive strategy; Standard methodologies for managing projects; Project life cycle; Design-implementation interface; Estimating: preliminary and detailed; Contractual risk allocation; Scheduling: PBS; WBS; Integration of scope, time, resource and cost dimensions of a project; Evaluation of labor, material, equipment, and subcontract resources; Scheduling techniques including CPM/ PERT, GERT, critical chain; Solving real-world project schedules; Monte Carlo simulation; Cost budgeting; Cost baseline; Cash flow analysis; Earned value analysis; Cost control; Proposal presentation; Application of software for project management (MS Project, Primavera Project Planner-P3).

EM-505 Operations Research

Deterministic modeling: Linear programming; The Simplex method; Multiple objective linear optimisation; Duality and sensitivity analysis; Post optimality analysis from the viewpoint of technology management; Transportation, transshipment, and assignment problems; Problem formulation; Goal programming; Network analysis; Dynamic programming; Integer programming and nonlinear programming. Probabilistic modeling: Markov chains; Queuing theory and applications; Inventory theory; Forecasting; Design analysis and simulation; Pareto optimality and tradeoff curves.

Common Electives Courses

EM-511 Total Quality Management

Critical principles and procedures of quality management in a competitive global environment; contemporary definitions of quality; construction quality; Product quality; Process quality; Quality economics; Quality philosophies; Planning, organising and controlling for quality; Human resource strategies; QA and QC tools.

EM-512 Project Evaluation and Feasibility Analysis

Evaluation of engineering projects from the engineering management perspective; Techniques for capital investment for decision-making; Time value of money and the concept of equivalence; Present worth, annual and rate of return analysis; Multiple alternatives; Replacement criteria; Tax considerations; Breakeven sensitivity analysis; Project evaluations under uncertainty; Risk sharing; Capital budgeting; Cost of capital depreciation; Multicriteria decisions. Project feasibility analysis; Organisational impacts; societal impacts; Environmental impacts.

EM-513 Research Methods in Engineering Management

Research methods in engineering and technology management; Statistical techniques including proper selection; Use and interpretation of parametric and non-parametric tests along with factor and discriminate analysis; Design of experiments and model misspecification; Simulation in engineering and management research and practice.

Electives Courses

EE-561 Power Generation Economics

Essentials of electrical energy generation and power systems; Load studies and effects of load variation; types of factors - demand, load, diversity and capacity; Load curves; base load and peak load stations; Interconnected Grid system and its advantages. Cost of electricity generation; types of costs - fixed, semi fixed and running; Methods of determining depreciation - straight line, diminishing value and sinking fund. Definition, objectives and desirables characteristics of Tariff; Types of tariff - Flat rate, Block rate, two part, maximum demand, power factor and three part tariff. Power factor and its economical aspects; Economics of Power Transmission.

EE-562 Energy Audits

Introduction: Need for Energy Consumption monitoring, Designing & starting energy consumption control programme, energy accounting, targeting and Reporting. Energy Audit Process: Preparations, facility inspections, audit procedures and action plans, audit reports, recommendations, implementation and follow ups of energy conservation schemes. Understanding Energy Bills: Electric rate structures, Natural gas rate schedule, steam & chilled water rate, costs of water and waste water. Monthly energy bill analysis, Actions to reduce electricity Utility costs. Utility incentives and rebates, electric utility competition and deregulation. Economic Analysis and Life Cycle Costing: Costs, categories of costs for capital investments cash flow diagrams and tables, simple payback period cost analysis, discounted cash flow analysis, cost effectiveness measures using discounted cash flows, benefit/cost (or savings/ investment) ratio, life cycle costing (LCC), LCC decision making, taxes and depreciation, inflation energy financing options.

EE-563 Energy Conservation

Introduction: Need for Energy Consumption and Conservation, Conservation schemes and implementation. Major areas of Energy Conservation. Lighting: Component of lighting System, Lamp types, Luminaries and types, maintenance of the lighting system and schedule, luminaries dirt depreciation factor, Re-lamping strategies, spot replacement and group Relamping strategies and costs. Lighting survey, Measuring Light levels. Regulatory/Safety issues, lighting safety issues, Energy Policy Act 1992. Task lighting, Lamp substitution, Lighting Control Technologies, selection of Lights for new facility. EPA Green lights programme. Electrical motors and transfonners - factors involving

selection and installation. Maintenance and overhaul scheduling. Performance tests. Depreciation factors. Energy System maintenance, transmission and distribution networks, HVAC systems, Boilers, steam distribution systems.

EE-564 Power System Restructuring

Energy Generation in the Modern Environment, Competitive Market for Generators and its advantages, Role of the existing power industry, Renewable Generation Technologies, Combined heat and power, Energy policy & Government Intervention, Costs. Deregulation of Electric Utilities: Traditional Central Utility model, reform motivations, separation of ownership and operations, competition and Direct Access in the electricity market Independent System Operation, Retail Electric Providers. Competitive Wholesale Electricity Market, Wholesale electricity market characteristics, Market Model, Challenges. Distribution in a Deregulated Market: The development of competition, key issues for distribution businesses Maintaining Distribution Planning, Distribution Automation, and Distributed Generation. Transmission Expansion In The New Environment: Role of Transmission Provider, Transmission Open Access, Trading Agreement, Transmission Pricing in open-access System, open-access Co-ordination Strategies; Case Studies.

EE-565 Distributed Generation

Sources of Electricity for Distributed Generation (IXi). Reasons, extent, issues and technical aspects of DG. Economic impacts of DG on transmission, distribution and central generation systems. Benefits and costs to the facility and utilities. Current technologies for DG- Embedded generation plants, combined heat and power plants, renewable energy generation- small scale hydro-generation, wind power plants, off-shore wind energy, solar photovoltaic generation, bio-mass energy, Fuel Cells. Power flow studies of a distributed generation scheme, balanced and unbalanced fault studies as applied to an embedded generation scheme. Analysis of existing facilities for possible DG application, Sensitivity analysis. Case studies.

EE-566 Reliability Engineering

Fundamentals of Reliability, Reliability through good design, through proper operations, through proper maintenance. Quantifying system reliability. Reliability through Probabilistic risk assessment. Reliability system modeling, reliability modeling, reliability block diagrams, Failure modes effects, Fault tree analysis.

Quality, Reliability & Maintainability: Definitions, management of quality control, economic aspects of quality decisions, capability & variability analysis, various aspects of life testing, reliability & maintainability. Introduction to ISO 9000 & ISO 14000.

EE-567 Energy Planning

Energy Economics and Planning: Energy Economics. The nature and causes of the energy problems. Demand-side and supply-side issues. Commercial and traditional energy determinants, externalities. Policy issues: pricing and distribution policies, energy balances- formulation and execution. National Energy statistics: Definitions of primary, secondary, delivered and useful energy. Problems of interpolation and comparison of energy statistics. Rural Energy Planning: Patterns of energy demand and supply. Socio-economic aspects of energy utilisation. Survey methods. Identifying potential solutions. Project planning, monitoring and execution. Financial Evaluation Projects: Project analysis and financial appraisal -discounted cash flow, Time preference discount rates. Inflation and interest rates. Project evaluation in terms of present values and internal.

EE-568 Reactive Power Management

Definition of terms used in Reactive Power Management. Quality in electrical power supply. Indices and cost of power quality, justification for capital cost, costing of reactive power. Reactive power requirement of utilities. Reactive power supply by utilities. Systems and tools for management of reactive power by utilities. User-side scenario of reactive power, management, compensation, planning, selection of equipments, consideration of harmonics. Reactive power management in different types of industrial plants.

MASTERS OF ENGINEERING (SMART GRID)

MASTERS OF ENGINEERING (SMART GRID)

List of Courses for the Masters of Engineering Programme in Smart Grid

Table 10 Smart Grid (Compulsory Courses)

Course No.	Course Title	Credit Hrs
EE-570	Advanced Electrical Power Systems	3
EE-571	Advanced Power Electronics	3
EE-572	Synchrophasor Technology	3
EE-573	Smart Grid Technologies and Applications	3
EE-574	Data Analytics for Smart Grid	3

Table 11 Smart Grid (Elective Courses)

Course No.	Course Title	Credit Hrs
EE-512	Advanced Digital Signal Processing	3
EE-575	Electricity Markets	3
EE-576	Communication System for Smart Grid	3
EE-577	Energy Storage Systems	3
EE-578	Renewable Energy Integration with Electrical Network	3
EE-579	Smart Grid System Security	3
EE-580	Power System Reliability	3
EE-581	Electrical Load Forecasting	3
EE-582	FACTS Devices and HVDC System	3
EE-583	Energy Management Systems	3
EE-531	Embedded Power Generation	3
EE-501	Linear Control System	3
EE-505	Digital Control System	3
EE-532	Reactive Power Control	3
EE-523	Power System Protection	3
EE-5002	Thesis	6

Detailed Contents of Courses for the M. Engg. Programme in Electrical Engineering (Smart Grid)

Compulsory Courses

Ee-570 Advanced Electrical Power System

Per unit system, reactance diagram, Distribution system and its components, voltage dependent load models – constant impedance, constant current and constant power, load characteristics, demand and demand interval, load flow analysis covering Gauss Seidal and newton Raphson method, Power system stability- voltage, angle and frequency, Power system protection- types of relays used and principles.

EE-571 Advanced Power Electronics

An introduction to Diode, thyristor, Gate turn off thyristors, BJTs, MOSFETs, IGBTs, principles of switch mode power conversion, DC-DC converters - DC Choppers, Buck Converter, Boost Converter, Buck-Boost Converter, C`uk Converter, Effects of Parasitics, AC-DC PWM rectifiers - Line-Commutated Controlled Rectifiers, force-Commutated Three-Phase Controlled Rectifiers, DC-AC PWM inverters - Single-Phase Voltage Source Inverters, three-Phase Voltage Source Inverters, Current Source Inverters. Grid interface of renewable energy resources, Soft switching and resonant converters, practical issues in power electronic converters, selection criteria for diodes, MOSFETs and IGBTs; gate drive circuit based on Thermal management, EMI and layout issues.

EE-572 Synchrophasor Technology

Phasor representation of Signals in time and frequency domains. Phasor estimation of Nominal and Off Nominal Frequencies, Quality of Phasor Estimates and Transient Monitors, Estimates of Unbalanced Input Signals, Frequency Estimation. Phasor Measurement Units and Phase Data Concentrators. Transient Response of Phasor Measurement Units. Phasor Measurement Applications

EE-573 Smart Grid Technologies and Applications

Smart Grid Definition, Need and Applications, Standardization

Smart Grid Communications Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems, Power Line Communications, Advanced Metering Infrastructure

Demand Response Definition, Applications, Pricing and Energy Consumption Scheduling, Controllable Load Models, Dynamics, and Challenges, Electric Vehicles and Vehicle-to-Grid Systems, Demand Side Ancillary Services

Wide Area Measurement Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges

Security and Privacy Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defense Mechanisms, Privacy Challenges

Economics and Market Operations Energy and Reserve Markets, Market Power, Generation Firms, Locational Marginal Prices, Financial Transmission Right.

EE-574 Data Analytics for Smart Grid

The Mathematical Foundations of Big Data Systems, Large Random Matrices, Linear Spectral Statistics of the Sample Covariance Matrix, Large Hermitian Random Matrices and Free Random Variables, Large Non-Hermitian Random Matrices, Probability Theory, Matrix Hypothesis Testing using Large Random Matrices, Applications and Requirements of Smart Grid, Grid Monitoring and State Estimation, False Data Injection Attacks against State Estimation, State Estimation, Minimum Mean Square Error (MMSE), State Estimation and Generalized Likelihood Ratio Test, Demand Response, Communications and Sensing.

Elective Courses

EE-501 Linear Control Systems

Properties of feedback control systems, Mathematical models of basic components, State-variable models of feedback systems, time-domain analysis, stability, transform analysis, frequency domain techniques, root-locus, design of single input-output systems, simple compensation techniques.

EE-505 Digital Control Systems

Examples of Discrete Data and Digital Control Systems, Signal Conversion and Processing, Sampling theorem, z-transform and inverse z-transform. The state-variable approach. Stability of Digital control system. Digital Simulation and digital redesign.

EE-512 Advanced Digital Signal Processing

Review of discrete signals and systems in temporal and spectral domains, data acquisition, discrete transforms (DFT, DCT and z-transforms), digital filters—HR and FIR, spectral estimation, adaptive filters, multi-rate signal processing, Wavelets and joint time-frequency analysis, and real-time signal processing.

EE-523 Power System Protection

Protective relaying philosophy and fundamental considerations, transmission lines, rotating machines and transformer protection, Relay input sources and their performance. Static relays. Basic components of static relays, Comparator, Basic static relays used in protective schemes.

EE-531 Embedded Power Generation

Reasons, extent, issues and technical impacts of embedded or dispersed generation. Economic impacts of embedded generation on transmission, distribution and central generation systems. Embedded generation plants, combined heat and power plants, renewable energy generation—small scale hydro-generation, wind power plants, off-shore wind energy, solar photovoltaic generation. Power flow studies of an embedded generation scheme, balanced and unbalanced fault studies as applied to an embedded generation scheme. Stability studies of an embedded generation scheme, electromagnetic transient studies, and generators for embedded generation, power quality and protection of embedded generation.

EE-532 Reactive Power Control

Definition of terms used in Reactive Power Management. Quality in electrical power supply. Indices and cost of power quality, justification for capital cost, costing of reactive power. Reactive power requirement of utilities. Reactive power supply by utilities. Systems and tools for management of reactive power by utilities. User-side scenario of reactive power management, compensation, planning, selection of equipments, consideration of harmonics. Reactive power management in different types of industrial plants.

EE-575 Electricity Markets

Electricity supply industry Structure, Operation and Management of the Electricity Supply Chain; Policy, Stakeholders, Influencers; Liberalization, Deregulation and Regulation; Market Structures for Electricity; Power Capacity; Location; Environment, Amenity, Corporate Responsibility; Price and Derivatives Modelling, relevant standards.

Designing wholesale physical electricity markets Characteristics and structures of electricity markets, Scarcity pricing: the role and design of balancing mechanisms and reserves, Managing congestion - Nodal pricing of power and other approaches, relevant standard practices in different countries.

Environmental policies and hybrid models Environmental policies and their impact on electricity markets Design of market compatible renewables support mechanisms

EE-576 Communication System for Smart Grid

Elements of power systems for communications and networking, SCADA systems, Smart meters, Advanced meter infrastructure (AMI). Advanced Metering Infrastructure Standards; Power line carrier communication (PLCC). Overview of smart grid network design and security, WAN and FAN Technology for smart grid, Smart grid data management, communication network transformation. Mediums of communication network and cost-benefit analyses including fibre-optics and wireless microwave links including 5G. Smart grid communication networks and protocols such as, IEEE 802.15.4, Zigbee, Z-wave, WiMAX, wireless routing protocols, GRPS and RPL, network performance with node failures, cyber security, network coding, cloud computing. Communication standards for substation and telecontrol, tele-protection equipment and their standards.

EE-577 Energy Storage Systems

Characteristics of Energy Storage System (ESS), Emerging needs for ESS, the roles of electrical energy storage technologies. Types of energy storage system covering mechanical storage systems, electrochemical storage systems, chemical energy storage, electrical storage systems, thermal storage systems. Standards for ESS, technical comparison of ESS technologies. Market for electrical energy storage (EES) covering Smart Grid, Smart Microgrid, Smart House, super capacitors, electric vehicles, Management and control hierarchy of storage systems covering battery storage systems, aggregating EES systems and distributed generation (Virtual Power Plant), Battery SCADA

EE-578 Renewable Energy Integration with Electrical Network

Distributed generation systems; Distributed Generation (DG) definition, types and standards for renewable energy and smart generation, optimum placement of DG, sizing, problems in integration with existing system.

DG operation and control: Inverter control voltage and current in DG systems; Parallel operation of inverters in distributed Generation systems; Power converter topologies for distributed Generation systems; Voltage and current control of a three-phase Four-wire DG inverter in Island mode; Power flow control of a single distributed Generation unit; Robust stability analysis of voltage and current Control for distributed generation systems; PWM rectifier control for three-phase Distributed Generation system; Integration of Multiple Renewable Energy Sources.

EE-579 Smart Grid System Security

Smart grid - Structure, challenges, need for security; European and other country approaches to Privacy and Data Protection in Smart Grids; The Evolution of the Smart Grid Threat Landscape and Cross-Domain Risk Assessment; Resilience Against Physical Attacks; Secure Communications in Smart Grid; Networking and Protocols; Cyber-Secure and Resilient Architectures for Industrial Control Systems; Establishing a Smart Grid Security Architecture; Secure Development Life Cycle; Operational Smart Grid Security; Implementation Experiences from Smart Grid Security Applications and Outlook on Future Research.

EE-580 Power System Reliability

Introduction to reliability, availability and power quality; Basic probability theory-Permutation and combination; Application of the binomial distribution; Network modelling and evaluation of simple systems; Network modelling and evaluation of complex systems; Probability distributions in reliability evaluation; System reliability evaluation using probability distributions; Distribution systems reliability—basic techniques and radial networks; Plant and station availability.

EE-581 Electrical Load Forecasting

Mathematical Background matrices, state space representation, optimization techniques, regression.

Static State Estimation Least error squares (LES) algorithm, least absolute value (LAV) algorithm to solve the linear static estimation problem, Linear constrained LAV problem and its solution, Nonlinear LAV problem and its solution.

Load Modeling for Short-Term Forecasting different models for short-term load forecasting, introducing three models for winter and summer short-term load forecasting, explaining different factors that affect these models for each season, fitting each model to the different techniques that are used to estimate the parameters of the model.

Fuzzy Regression Systems and Fuzzy Linear Models covering fuzzy fundamentals, fuzzy set theory, fuzzy linear estimation and regression, fuzzy Short-Term Load Modeling.

Dynamic State Estimation Discrete Time Systems, Discrete Time-Optimal Filtering, Recursive Least Error Squares.

Load Forecasting - Load Forecasting using Static State Estimation, Load Forecasting Using Fuzzy Systems, Dynamic Electric Load Forecasting, Electric Load Modeling for Long-Term Forecasting.

EE-582 FACTS Devices and HVDC System

FACTS (Flexible Alternating Current Transmission) concepts: Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, types of FACTS controllers.

Static shunt and series compensators: Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators – SVC, STATCOM, SVC and STATCOM comparison.

Combined compensators: Unified power flow controller (UPFC) and Interline power flow controller (IPFC) - Introduction, operating principle, independent real and reactive power flow controller and control structure, concepts relating to Reactive power compensation and harmonic current compensation using Active power filters

HVDC (High Voltage Direct Current) transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC system. HVDC Converters. **Control of HVDC system:** Principles of control, Different control features, Introduction to multiterminal DC systems and applications, comparison of series and parallel MTDC systems, Voltage Source Converter based HVDC systems.

EE-583 Energy Management System

Energy Auditing: Load calculations, heating load calculation, lighting load calculations, ISO standards, rate of return calculations, life cycle assessment, energy metering, tariff calculations, two-way metering.

Smart Home: Energy efficient loads, smart and energy efficient devices, PV and wind installation, application of IoT in smart home, recent trends and technologies; Smart Home and Building Automation Standards

Battery Management System (BMS): Operation and working of electrochemical batteries, Lithium ion batteries, battery management system and requirement for sensing and high voltage control, BMS design requirements.

Electric Vehicles (EV): EV vs. gasoline cars, EV working, Electric motors, Regenerative braking, motor selection, storage technology for EV, Charging of technologies for EVs. Standards for smart storage and plug-in electric vehicles, including standards for electric storage, and E-mobility/plug-in vehicles