PUNJAB TECHNICAL UNIVERSITY

Scheme and Syllabus
of
Master of Technology
(Electrical Engineering)
Batch 2013

By
Board of Studies Electrical Engineering

Semester –I

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
MTRM-101	Research Methodology	3	1	0	50	100	150	4
MTEE-101	Power System Analysis and Design	3	1	0	50	100	150	4
MTEE-102	Advanced Power Electronics	3	1	0	50	100	150	4
MTEE-103	Advanced Electrical Machines	3	1	0	50	100	150	4
MTEE-104	Digital Control System	3	1	0	50	100	150	4
	Total	15	5	0	250	500	750	20

Semester –II

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
MTEE-201	Power System Operation and Control	3	1	0	50	100	150	4
MTEE-202	Advanced Relaying and Protection	3	1	0	50	100	150	4
MTEE-203	Modeling and Dynamics of Electrical Machines	3	1	0	50	100	150	4
MTEE-204X	Elective-I	3	1	0	50	100	150	4
MTEE-205Y	Elective-II	3	1	0	50	100	150	4
	Total	15	5	0	250	500	750	20

Semester –III

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
MTEE-301X	Elective-III	3	1	0	50	100	150	4
MTEE-302Y	Elective-IV	3	1	0	50	100	150	4
MTEE-303	Project	-	-	4	100	50	150	3
MTEE-304	Seminar	-	-	2	50	-	50	1
MTEE-305	Dissertation (Synopsis)	-	-	6	-	-	-	-
	Total	6	2	12	250	250	500	12

Semester –IV

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
MTEE-305	Dissertation	-	-	20	-	-	-	-
	Total	-	-	20	-	-	-	-

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Elective	Electrical Engineering	
Elective-I	MTEE-204A	Intelligent Techniques and Applications
	MTEE-204B	Industrial Drives and Automation
	MTEE-204C	Renewable Energy Resources
	MTEE-204D	High Voltage Engineering and Test Techniques
Elective-II	MTEE-205A	Special Electric Machines
	MTEE-205B	Microprocessor and Microcontroller
	MTEE-205C	Real Time Instrumentation
	MTEE-205D	Optimization Techniques
Elective-III	MTEE-301A	Energy Efficient Machines
	MTEE-301B	Power System Dynamics and Stability
	MTEE-301C	EHVAC and HVDC Transmission System
	MTEE-301D	Power System Transients
Elective-IV	MTEE-302A	Power System Reliability
	MTEE-302B	Power System Planning
	MTEE-302C	Load and Energy Management
	MTEE-302D	Organization and Finance in Power Sector

MTMA-101 RESEARCH METHODOLOGY

			L	T	P
Internal Marks:	40		3	1	0
External Marks:	60				
Total Marks:	100				

METHODS OF RESEARCH: Nature and Objectives of research; historical, descriptive and experimental. Study and formulation of research problem. Scope of research and formulation of hypotheses; Feasibility, preparation and presentation of research proposal.

INTRODUCTION TO STATISTICAL ANALYSIS: Measures of central tendency and dispersion: mean, median, mode, range, mean deviation and standard deviation. Regression and correlation analysis. Probability and probability distributions; Binomial, Poisson, Geometric, Negative binomial, Uniform, Exponential, Normal and Log-normal distribution. Basic ideas of testing of hypotheses; Tests of significance based on normal, t and Chi-square distributions. Analysis of variance technique.

DESIGN OF EXPERIMENTS: Basic principles, study of completely randomized and randomized block designs. Edition and tabulation of results, presentation of results using figures, tables and text, quoting of references and preparing bibliography. Use of common softwares like SPSS, Mini Tab and/or Mat Lab. For statistical analysis.

BOOKS RECOMMENDED:

1. Borth Wayne C., *The Craft of Research*, Chicago Guides to Writing Edition and Publishing.

2. Johnson R.A., *Probability and Statistics*, PHI, New Delhi.

3. Meyer P.L., *Introduction to Probability and Statistical, Applications*, Oxford, IBH.

4. Hogg, R.V. and Craig A.T., *Introduction to Mathematical Statistics*, MacMillan.

5. Goon, A.M., Gupta, M.K. and Dasgupta, *Fundamentals of Statistics*, Vol. I: World Press.

6. Gupta, S.C. and Kapoor V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons.

MTEE-101 POWER SYSTEM ANALYSIS AND DESIGN

		L	**T**	**P**
Internal Marks:	40	**3**	**1**	**0**
External Marks:	60			
Total Marks:	100			

OVERVIEW: Review of modeling of power system components, formulation and modifications of the Impedance and Admittance matrices, storage techniques.

OPTIMAL POWER FLOW: Review of load flow with and without tap changing and phase shifting transformer, load flow for radial (distribution) systems, Optimal power flow (OPF) problem formulation and solution techniques.

FAULT STUDIES: Three Phase Networks, Three Phase Network Elements, Balanced Network, Transformation Matrices, Three Phase Unbalanced network Elements, Algorithm formation of Three Phase Bus Impedance Matrix, Modification of Three Phase Bus Impedance Matrix for changes in the Network.

NETWORK FAULTS AND CEONTINGENCY ANALYSIS: Fault computation using Z – Bus, Short Circuit Calculation for Three Phase Network using z-bus, Contingency analysis for power system.

POWER SYSTEM SECURITY: Factors affecting security, Contingency analysis, Network sensitivity using load flow, correcting the generation dispatch by using sensitivity method and linear programming.

STATE ESTIMATION IN POWER SYSTEMS: Method of least-squares, State estimation of AC network, Detection and identification of bad measurements, Network observability and pseudo measurements, Application of power system state estimation.

BOOKS RECOMMENDED:

1. Grainger J.D., *Power System Analysis*, McGraw-Hill, Inc, Singapore.

2. Wood A.J. and Wollenberg B.F., *Power Generation, Operation and Control*, John Wiley and Sons, New York, USA.

3. Glover J.D. and Sarma, *Power System Analysis and Design*, PWS Publishing Company, Boston, USA.

4. Stagg G. W. and Elabiad A. H., *Computer Methods in Power System Analysis*, McGraw Hill, New York.

5. Pai M. A., *Computer Techniques in Power System Analysis*, Tata McGraw Hill Publishing Co. Ltd.

6. Kusic G.L., *Computer Aided Power System Analysis*, Prentice Hall (India)

7. Arrillaga J., Arnold C.P. and Harker S.J. , *Computer Modeling of Electrical Power Systems*, John. Willey and Sons 1983.

8. Elgard O.I., *Electric Energy Systems An Introduction*, Tata McGraw Hill, 1971.

MTEE-102 ADVANCED POWER ELECTRONICS

				L	**T**	**P**
Internal Marks:	40			**3**	**1**	**0**
External Marks:	60					
Total Marks:	100					

REVIEW OF SEMICONDUCTOR DEVICES: Conduction Process in semiconductors, pn Junction, Charge control description, Avalanche breakdown, Power diodes, Thyristors, Gate Turn Off thyristor (GTO), VI characteristics, Dynamic characteristics, ratings, protection, heat transfer by conduction, radiation and convection, heat sink design, driving circuits.

POWER MOSFET AND IGBT: Basic structure, I-V Characteristic, Physics of device operation, switching characteristics, operating limitation and safe operating area.

EMERGING DEVICES AND CIRCUITS: Power junction Field effect transistor (FET), Integrated Gate-Commutated Thyristor (IGCT), Field Control Thyristor, Metal oxide semiconductor (MOS) Control Thyristor etc. Power ICs, New semiconductor materials.

SNUBBER CIRCUITS: Types of Snubber circuits, needs of Snubber circuit with diode, thyristor and transistors, Turn-off Snubber, over voltage snubber, turn on snubber, Snubber for bridge circuit configurations, GTO Snubber circuit.

GATE AND BASIC DRIVE CIRCUITS: Design Consideration, De-coupled drive circuits, Electrically isolated drive circuits, cascade connected drive circuits, Power device protection in drive circuits, circuit layout considerations.

BOOKS RECOMMENDED:

1. Mohan, Undeland and Robbins, *Power electronics: converters, Applications and Design*, John Wiley and Sons.

2. Rashid M.H., *Power Electronics Handbook*, Elsevier Press (Academic Press Series).

3. Finney D., *The Power Thyristor and its Applications*, McGraw Hill, New York.

4. Lander C. W. *Power Electronics*, McGraw Hill Book Co., U.K.

5. Rashid M.H., *Power Electronics* - Circuits, Devices and Applications, PHI, India.

MTEE-103 ADVANCED ELECTRICAL MACHINES

				L	T	P
Internal Marks:	40			3	1	0
External Marks:	60					
Total Marks:	100					

POLYPHASE SYNCHRONOUS MACHINES: Mathematical: Basic Synchronus machine parameters, Voltage, Flux linkage and inductance relations, Park's transformation – its physical concept, equations of performance

BALANCED STEADY STATE ANALYSIS: Phasor equations and phasor diagrams, Power-angle characteristics, Cylindrical rotor and Salient pole machines, Short circuit ratio.

TRANSIENT ANALYSIS: Three phase short-circuits, Armature and field transients, Transient torque, Sudden reactive loading and Unloading. Transient Analysis - a qualitative approach, Reactances and Time – Constants from equivalent circuits, Measurement of Reactances, Transient Power – angle characteristics.

SYNCHRONOUS – MACHINE DYNAMICS: The basic electromechanical equation, Linearized Analysis, Large Angular/oscillation, Non-linear analysis.

TRANSFORMERS: Multi-Circuit Transformers: General theory, Equivalent circuits, Three winding transformer as a multi-circuit transformers, Determination of parameters.

EXCITATION PHENOMENA IN TRANSFORMERS: Hamonics in Single – phase transformers, Harmonics in three-phase transformers, Disadvantages of harmonics, Suppression of harmonics.

TRANSFORMER TRANSIENTS: In-rush current phenomena, Qualitative approach, Analytical approach, In-rush current in 3-phase transformers.

UNBALANCED OPERATION OF THREE-PHASE TRANSFORMERS : Single-phase load on three-phase transformers, Single – Phasing in 3-phase transformers, Effect of using tertiary winding.

BOOKS RECOMMENDED:
1. Edikins B. ,*Generalized theory of electrical Machines*,
2. Concordia, *Synchronous machines*.
3. E.W. Kimbark , *Power System Stability*, Vol. III., Wiley
4. Fitzgerald A.E., Kingsley C. and Umans S.D., *Electric Machinery*, 6th Edition, McGraw Hill
5. Bimbra, P.S.,*Generalized theory of electrical Machines*, Khanna Publications
6. Draper A, *Electrical Machines,* Longman London, 1972
7. MIT Staff , *Magnetic Circuits and Transformer.*.
8. Daniels A. R., *Introduction to Electrical Machines*" MacMillan, London 1976.

MTEE-104 DIGITAL CONTROL SYSTEM

				L	T	P
Internal Marks:	40					
External Marks:	60			**3**	**1**	**0**
Total Marks:	100					

SIGNAL PROCESSING IN DIGITAL CONTROL: Digital control, Configuration of the basic Digital control scheme, Principles of signal conversion, Basic Discrete-Time signals, Time-Domain Models for Discrete Time Systems, Transfer function Model, Stability in the Z-Plane and Jury stability criterion, Sampling as impulse modulation, Sampled spectra and Aliasing, Filtering, Practical aspects of the choice of sampling rate, Principles of Discretization, The Routh stability Criterion.

MODELS OF DIGITAL CONTROL DEVICES and SYSTEMS: Z – Domain, Description of Sampled continuous – Time Plants, Z- Domain Description of Systems with Dead Time, Implementation of Digital Controllers, Digital temperature Control System, Digital Position Control System, Stepper motors and their control.

DESIGN OF DIGITAL CONTROL ALGORITHMS: Z-Plane specifications of control system design, Digital Compensator Design using frequency response plots, Digital Compensator design using root locus plots, Z – Plane Synthesis.

CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS: State Variable representation, Conversion of state Variable models to Transfer functions, Conversion of Transfer functions to Canonical state Variable models, Eigen values and Eigen Vectors, Solution of state equations, Concepts of Controllability and Observability, Equivalence between transfer function and State Variable Representation, Multivariable systems. State descriptions of Digitals Processors, State description of Sampled continuous – Time Plants, State description of Systems with dead Time.

Recommended Books:

1.   Raven, F.H., *Automatic Control Engg.* , McGraw Hill Book Company.

2.   Shinners, S.M., *Modern Control System Theory and Design*, John Wiley and Sons.

3.   Kuo, B.C., *Automatic Control System*, Prentice Hall.

4.   Ogata, K., *Modern Control Engineering*, Prentice Hall.

5.   Nagrath, I.J., and M. Gopal*, Control Systems Engg.* John Wiley and Sons.

MTEE-201 POWER SYSTEM OPERATION AND CONTROL

Internal Marks: 40   **L   T   P**
External Marks: 60   **3   1   0**
Total Marks: 100

INTRODUCTION: Characteristics of power generation units(thermal, nuclear, hydro, pumped hydro), variation in thermal unit characteristics with multiple valves, Economic dispatch with and without line losses, lambda iteration method, gradient method, Economic dispatch without line losses, economic dispatch with line losses, lambda iteration method, gradient method, Newton's method, base point and participation factors.

TRANSMISSION LOSSES: Coordination equations, incremental losses, penalty factors, B matrix loss formula (without derivation), methods of calculating penalty factors.

UNIT COMMITMENT: constraints in unit commitment, priority list method, Dynamic programming method and Lagrange relaxation methods.

HYDRO THERMAL CO-ORDINATION: Introduction to long range and short range hydro scheduling, Types of short range scheduling problem, Scheduling energy. The short term hydro-thermal scheduling problems and its solution by Lambda-Gamma iteration method and gradient method

GENERATION WITH LIMITED ENERGY SUPPLY: take or pay fuel supply contract, composite generation production cost function, gradient search techniques.

OPTIMAL POWER FLOW FORMULATION: gradient and Newton method, linear programming methods.

AUTOMATIC VOLTAGE REGULATOR: load frequency control, single area system, multi-area system, tie line control.

BOOKS RECOMMENDED:

1. Kothari D.P. and Dhillon J.S., *Power System Optimization*, Prentice-Hall of India Pvt. Ltd. New Delhi
2. G L.K .Kirchmayer, *Economic Operation of Power Systems*, John Willey and Sons,N.Y.
3. Wood A.J, Wollenberg B.F , *Power generation operation and control.*
4. Kothari D.P. and Nagrath I.J., *Modern Power System Analysis* ,Tata Mc Graw-Hill Publishing Company Ltd., New Delhi

MTEE-202 ADVANCED RELAYING AND PROTECTION

				L	**T**	**P**
Internal Marks:	40			3	1	0
External Marks:	60					
Total Marks:	100					

PROTECTIVE RELAYING: Relay terminology, Definitions, Classification, electromechanical, static and digital-numerical relays. Design-factors affecting performance of a protection scheme for various faults, Instrument transformers for protection.

RELAY SCHEMATICS AND ANALYSIS: Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types- Characteristics.

PROTECTION OF POWER SYSTEM EQUIPMENTS: Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes.

SYSTEM GROUNDING: Ground faults and protection; Load shedding and frequency relaying; Out of step relaying; Re-closing and synchronizing.

BASIC ELEMENTS OF DIGITAL PROTECTION: Digital signal processing – Digital filtering in protection relay – digital data transmission – Numeric relay hardware – relay algorithm – distance relays – direction comparison relays – differential relays – software considerations – numeric relay testing –concept of modern coordinated control system.

INTEGRATED AND MULTIFUNCTION PROTECTION SCHEMES: SCADA based protection systems, Testing of Relays.

BOOKS RECOMMENDED:

1. John A T and Salman A K, *Digital protection for power systems-IEE power series-15*, Peter Peregrines Ltd,UK,1997

2. Mason C.R., *The art and science of protective relaying,* John Wiley &sons, 2002

3. Reimert Donald, *Protective relaying for power generation systems*, Taylor & Francis-CRC press 2006

4. Gerhard Ziegler,*Numerical distance protection*, Siemens, 2nd ed, 2006

5. Warrington A.R., *Protective Relays*, Vol .1&2, Chapman and Hall, 1973

6. T S.Madhav Rao, *Power system protection static relays with microprocessor applications*, Tata McGraw Hill Publication, 1994

8. Badri Ram , D.N. Vishwakarma, *Power system protection and switch gear*, Tata McGraw Hill, 2001

9. Blackburn, J. Lewis , *Protective Relaying, Principles and Applications*, Marcel Dekker, Inc., 1986.

10. Anderson, P.M, *Power System Protection*, McGraw-Hill, 1999

11. Singh L.P., *Digital Protection, Protective Relaying from Electromechanical to Microprocessor*, John Wiley & Sons, 1994

MTEE-203 MODELING AND DYNAMICS OF ELECTRICAL MACHINES

Internal Marks: 40   **L   T   P**
External Marks: 60   **3   1   0**
Total Marks: 100

INTRODUCTION: Challenges in computer simulations, Mechanics of simulation, solution techniques for time domain analysis, introduction of widely used circuit- oriented simulators like Pspice, MATLAB, PSIM, equation solvers, simulation of power electronics circuits and converters,

DYNAMIC CONDITIONS: Concept, constraints and considerations; modeling and performance simulation methods, concept of reference frame, generalized transformation, formulation of dynamic equations of a generalized machine in arbitrary reference frame.

D.C. MACHINES DYNAMICS: Ideal machine; dynamic equation; transfer function and block diagram; linear analysis of D.C. generators; effects of saturation; analysis and performance under disturbances. Switching and surge voltage transients in transformers.

INDUCTION MACHINES: Transients and dynamics; basic electro mechanical equations; linearized and non-linearized analysis; operation on harmonic supplies; unbalanced operation.

SYNCHRONOUS MACHINE TRANSIENTS: Coupled circuit viewpoint; approximate physical picture; equivalent circuit under transient conditions and its applications; synchronous motor operation with variable/fixed load torque and excitation; equal-area criterion for the study of transient stability.

BOOKS RECOMMENDED:

1. Krause P.C., *Electric Machinery*, McGraw Hill.

2. Kimbark E.W., *Power System Stability* Vol 3 Synchronous Machine, John Wiley and Sons.

3. Concordia C., *Synchronous machines*, Theory and Performance, John Wiley and Sons.

4. Adkins B. and Harley R. G., *The General theory of Alternating Current Machines*, Chapman and Hall.

5. Ong Chee Mun, *Dynamic Simulation of Electric Machinery using MatLab and Simulink*, Pentice Hall (India), New Jersey

MTEE-204A INTELLIGENT TECHNIQUES AND APPLICATIONS

			L	**T**	**P**
Internal Marks:	40		**3**	**1**	**0**
External Marks:	60				
Total Marks:	100				

ARTIFICIAL INTELLIGENCE: Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic.

FUZZY LOGIC: Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

ARTIFICIAL NEURAL NETWORK: Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

EVOLUTIONARY TECHNIQUES: Introduction and concepts of genetic algorithms and evolutionary programming, Differential Evolution

HYBRID SYSTEMS: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems

AI APPLICATIONS IN POWER SYSTEMS: Load flow, economic load dispatch, load forecasting, transient stability and power system stabilizers

BOOKS RECOMMENDED:

1. Rajasekaran S. and Pai G.A.V., *Neural Networks, Fuzzy Logic And Genetic Algorithm Synthesis and applications*, PHI New Delhi.

2. Lin C. and Lee G., *Neural Fuzzy Systems*, Prentice Hall International Inc.

3. Goldberg D.E. *Genetic Algorithms in Search Optimization and Machine Learning*, Addition Wesley Co., New York.

4. Kosko B., *Neural Networks and Fuzzy Systems A dynamical systems approach to machine intelligence*, Prentice Hall of India.

5. Taylor C.W., *Power System stability* Mc-Graw Hill, New York.

6. Shivnandam S.N., *Principle of soft computing,* Wiley.

7. RajshekaranS. and Pa G.A.V.i, *Neural Network , Fuzzy logic And Genetic Algorithm, PHI.*

8. Zurada Jack M., *"Introduction to Artificial Neural Network System"* JAICO Publication.

9. Ross Timothy J.*, "Fuzzy logic with Engineering Applications",* McGraw-Hills

MTEE-204B INDUSTRIAL DRIVES AND AUTOMATIONS

				L	**T**	**P**
Internal Marks:	40			3	1	0
External Marks:	60					
Total Marks:	100					

INTRODUCTION: Definition, Types of loads, steady state and transient stability of Drive, state of art of power electronics and drives, selection of motor rating.

D.C. DRIVES: Review of braking and speed control of D.C. motors, multi-quadrant operation, loss minimization in adjustable speed drives. Mathematical modeling of dc drives, stability analysis, modern control techniques: variable structure, adaptive control.

INDUCTION MOTOR DRIVES: Review of braking and speed control of induction motors. Constant V/F, constant air gap flux, controlled voltage, controlled current and controlled slip operation, vector control, Mathematical modeling of induction motor drives, transient response and stability analysis Introduction to cycloconverter fed induction motor drive.

SYNCHRONOUS MOTOR DRIVES: Adjustable frequency operation, voltage fed drive, current fed self-controlled drive.

AUTOMATION USING DRIVES: Introduction, various components of automation, different sensors used in automation, PLC introduction and ladder programming, industrial application of automation, sensor less vector control and DTC drive, Recent trends in automation and case studies.

BOOKS RECOMMENDED:

1. Dubey G.K., *Power Semiconductor Controlled Drive*, Prentice Hall, New Jersey.

2. Sen P.C., *Thyristor Controlled DC Drives*, Wiley, New York.

3. Murphy J.M.D. and Turnbull F.G., *Power Electronics Control of AC Motors*, Franklin Book Co.

4. Bose B.K., *Power Electronics and AC Drives*, Prentice Hall, New Jersey.

5. Bose B.K., *Power Electronics and Variable Frequency Drives-Technology and applications*, IEEE Press.

MTEE-204C RENEWABLE ENERGY RESOURCES

				L	**T**	**P**
Internal Marks:	40					
External Marks:	60			**3**	**1**	**0**
Total Marks:	100					

ENERGY RESOURCES: Renewable energy sources, Environment, Energy and Global Climate Change energy parameters, cogeneration, rational use of energy, energy efficiency and conservation, distributed energy systems and dispersed generation, atmospheric aspects of electric energy generation, Impact of renewable energy generation on environment, GHG emissions from various energy sources, Electromagnetic Radiation from Extra High Voltage Overhead lines

SOLAR ENERGY: Solar Radiation and its Measurement, Solar Thermal Energy Collectors, Solar Thermal Energy Conversion Systems, Solar Photovoltaic System.

WIND ENERGY: Wind turbines and rotors, Wind Energy Extraction, Wind Characteristics, Power Density Duration Curve, Design of Wind Turbine Rotor, Design of Regulating System for Rotor, Wind Power Generation Curve, Sub-systems of a Horizontal Axis Wind Turbine Generator, Modes of Wind Power Generation, Estimation of Wind Energy Potential, Selection of Optimum Wind Energy Generator (WEG), Grid Interfacing of a Wind Farm, Methods of Grid Connection, Grid System and Properties, Capacity of Wind Farms for Penetration into Grid, Control System for Wind Farms, Economics of Wind Farms

GEOTHERMAL ENERGY: Structure of the Earth's Interior, Plate Tectonic Theory, Geothermal Sites, Geothermal Field, Geothermal Gradients, Geothermal Resources, Geothermal Power Generation, Geothermal Electric Power Plant, Geothermal-Preheat Hybrid with Conventional Plant

OCEAN ENERGY: Development of a Tidal Power Scheme, Grid Interfacing of Tidal Power, Wave Energy, Mathematical Analysis of Wave Energy, Empirical Formulae on Wave Energy, Wave Energy Conversion, Principle of Wave Energy plant, Wave Energy Conversion Machines

FUEL CELLS: Principle of Operation of Fuel Cell, Fuel Processor, Fuel Cell Types, Energy Output of a Fuel Cell, Efficiency, and EMF of a Fuel Cell, Operating Characteristics of Fuel Cells, Thermal Efficiency of a Fuel Cell

HYDROGEN ENERGY SYSTEM: Hydrogen Production, Hydrogen Storage, Development of Hydrogen Cartridge, Gas Hydrate

HYBRID ENERGY SYSTEMS: Hybrid Systems AND ITS Types, Electric and Hybrid Electric Vehicles, Hydrogen-Powered-Electric Vehicles.

BOOKS RECOMMENDED:

1. Kothari DP, Singal KC and Ranjan Rakesh, *Renewable energy sources and emerging technologies*, 2nd ed, Prentice Hall (India)

2. G.D. Rai, *Non-Conventional Sources of Energy*, Khanna Publishers.

3. Bansal N.K., M. Kleemann, M. Heliss, *Renewable energy sources and conversion technology*, Tata McGraw Hill 1990.

4. Abbasi SA, Abbasi N, *Renewable energy sources andtheir environmental impact,* PHI, 2001

5. Mittal KM, *Renewable energy Systems,* Wheelar Publishing, New Delhi, 1997.

6. Mukherjee D, *Renewable energy Systems,* New Age International, New Delhi, 2004

MTEE-204D HIGH VOLTAGE ENGINEERING AND TEST TECHNIQUES

		L	**T**	**P**
Internal Marks:	40			
External Marks:	60	3	1	0
Total Marks:	100			

INTRODUCTION: Power Systems Development and High Voltage Engineering; Contents of High Voltage Engineering; Applications of High Voltage Technology.

TRAVELING WAVES: Transient and traveling waves; Effects of Line Terminations; Junction of several lines; Bewley Lattice Diagram; Traveling wave in transformer and generator.

LIGHTNING IN POWER SYSTEMS: Lightning formation; Lightning overvoltages (strike and backflashover) in power systems; Lightning overvoltages protection devices in power systems; Lightning protection system of high buildings.

SWITCHING OVER VOLTAGES: Types of internal overvoltages; The importance of switching overvoltages; Causes of various internal overvoltages; Control of switching overvoltages; EMTP and its applications.

ARRESTERS AND INSULATION COORDINATION: Surge arresters (MOA) and its performances; Voltage-Time Characteristics and coordination; Surge arresters selection and location in power systems; Principles of insulation coordination; Statistical and conventional insulation coordination.

HIGH VOLTAGE CABLES: Configuration and design features of high voltage cables; Testing of high voltage cables; Diagnostics of high voltage cables.

AIR AND SF6 BREAKDOWN: Fundamental aspects of air and SF6 breakdown, U-curve and gap factor; Sparkover characteristics; SF6 gas insulation performance.

GAS INSULATED SUBSTATION: Gas Insulated Substation (GIS) and its importance; Configuration and design features of GIS; Prospects of GIS.

HIGH VOLTAGE TEST OF ELECTRICAL APPARATUS: Nondestructive insulation testing; Destructive insulation testing: AC, DC, and Impulse testing of apparatus; New high voltage measurement technology; Safety in high voltage lab. Applications of high voltages technology in other area.

BOOKS RECOMMENDED:

1. Khalifa M., *High-Voltage Engineering*, Theory and Practice, Marcel Dekker, Inc.

2. Ryan H.M., *High Voltage Engineering and Testing*, IEE Press.

3. Gonen T., *Electric Power Distribution System Engineering*: Analysis and Design, McGraw Hill Book Co.

MTEE-205A SPECIAL ELECTRIC MACHINES

Internal Marks:	40	**L T P**
External Marks:	60	**3 1 0**
Total Marks:	100	

SPECIAL AC MACHINES: Constructional aspects, design and analysis of reluctance, shaded pole, hysteresis, printed circuit, claw motors, Servomotors and A.C. tacho-generators, Introduction of permanent magnet materials. Angled field and axial field devices; cross-field machines, special forms of rotating amplifiers. Electromagnetic clutches, coupling and brakes, Eddy current devices.

LINEAR MACHINES: Linear devices and actuators, Linear electric machines: Classification, application, constructional aspects, design and method of analysis of various types, Goodness factor.Transverse-edge, entry-end, exit end, short primary, short secondary effects in linear electric motors, Force, energy and power LEM's for low speed medium speed and high speed applications. Electromagnetic levitation and guidance schemes-attraction, repulsion

ADVANCED MOTORS AND DRIVE SYSTEMS: Principle, construction, operation and drive application of Square wave Permanent Magnet (PM) brushless motor drives, sine wave PM brushless motor drives, PM and synchronous reluctance based motors, switched reluctance motors, Energy efficient motors.

RECOMMENDED BOOKS:

1. Bose B.K., *Power Electronics and variable frequency drives,* Prentice Hall, New Jersey.

2. Miller T.J.E., *Brushless permanent magnet and reluctance motor drives*, Oxford University Press, UK

3. Nasar S.A., *Linear induction motor*, John Wiley, New York

4. Andreas J.C., *Energy Efficient Motors*, Marcel Dekker

5. Murphy J.M.P., *Power Electronics control of AC Drives*, Pergamon Press

MTEE-205B MICROPROCESSOR AND MICROCONTROLLERS

Internal Marks: 40   **L   T   P**
External Marks: 60   **3   1   0**
Total Marks: 100

MICROPROCESSOR: 8086 Internal Architecture, Addressing modes, program development steps, 8086 instruction set, Assembler directives, Assembly language, program development tools.

PROGRAMMING OF 8086: Simple sequence programs, jumps, flags, conditional Jumps, IF-THEN, IF-THEN-ELSE, Multiple IF-THEN-ELSE, WHILE-DO, REPEAT-UNTIL, Instruction Timing and delay loops, strings, procedures, Macros.

PERIPHERAL INTERFACING: Parallel versus serial transmission, synchronous and asynchronous serial data transmission. Interfacing or hexadecimal keyboard and display unit, parallel, serial interface Standards.

MICROPROCESSOR APPLICATIONS TO POWER ENGINEERING: Protective Relaying: over-current, impedance, MHO, reactance, bi-directional relays.

MEASUREMENTS: Frequency, power angle and power factor, Voltage and Current, kVA, kW, and kVAR, maximum demand. Resistance, Reactance, Temperature Controls.

Microcontroller: PICi8 family- Microcontroller, architecture, Addressing Modes, Timers, Counters, Interrupts, Serial Communication, Instruction Set and Programming Concepts and applications to Electric Drive Systems

BOOKS RECOMMENDED:

1.   Rafiquzzaman, *M. Theory and Applications*, Prentice Hall (India) Publications 1993.

1.   Ram B, *Fundamentals of Microprocessors and Microcomputers*, Dhanpat Rai and Sons,
2.   Hall, Douglas V. *Microprocessors and interfacing: Programming and Hardware*, Tata McGraw Hill
3.   Brey, Barry B., *The INTEL Microprocessors 8086/88, 80186, 286, 386, 486, Pentium Pro Processors, Architecture, Programming and Interfacing*, 4th Edition, Prentice Hall (India)
4.   Ray A.K. and Bhurchandi K.M., *Advanced Microprocessors and Peripherals*, Tata McGraw Hill.
5.   Mazidi M.A. et. al. *The PIC- Micro-controller and Embedded Systems,* Pearson Publication
6.   Gaonkar R. S., *Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC*, Thomson learning

MTEE-205C REAL TIME INSTRUMENTATION

			L	T	P
Internal Marks:	40		**3**	**1**	**0**
External Marks:	60				
Total Marks:	100				

INTRODUCTION: Static and Dynamic characteristics, Error analysis; transducers and sensors; their characteristics and parameters; role of instrumentation in monitoring, control and industrial automation.

SIGNAL CONDITIONING: Amplifiers, multiplexers and dividers, timer multiplexers, Signal converters, ADC and DAC, Signal conditioning, digital signal conditioning, transmission of digital signals, Telemetry methods and errors, PLCC, AM, FM, PAM, PWM, PCM Techniques.

DATA ACQUISITION SYSTEM: Role of dedicated computers, analog and digital control, computer systems for real time applications, distributed and supervisory control, SCADA and its organization and structure, centralized, hierarchical and decentralized control schemes, man machine interface, energy management system.

REAL TIME CONTROL APPLICATIONS: Instrumentation and conditioning of drive signals, data acquisition of drive system, energy management system for AGC, VAR Control, state estimation, security monitoring, economic dispatch, on line load management. Power system digital relaying, Power plant instrumentation.

BOOKS RECOMMENDED:

1. Torsten Cegrell, *Power System Control Technology*, PHI, India.

2. Kusic C. L., *Computer Aided Power System Analysis*, TMH, New Delhi.

3. Wood A. J. and Wollenberg B., *Power generation operation and control*, John Wiley.

4. Cerni R.H and Foster L.E., *Instrumentation for Engineering Management*, John Wiley and Sons.

MTEE-205D OPTIMIZATION TECHNIQUES

Internal Marks: 40   **L   T   P**
External Marks: 60   **3   1   0**
Total Marks: 100

INTRODUCTION TO OPTIMIZATION: Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engg. applications of optimization.

CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with in equality constraints.

LINEAR PROGRAMMING: Standard form of linear programming ,Graphical solution, Simplex method, Twophase simplex method, Computer implementation of the simplex method, Duality theory.

TRANSPORTATION PROBLEM: North-West Corner rule, Least cost method, Vogel approximation method, testing for optimality.

NON-LINEAR PROGRAMMING:

One–Dimensional Minimization Methods: Unimodal function, Dichotomous search, Fibonacci search, Golden Section, Cubic interpolation method, Direct root, Newton Raphson Method

Unconstrained Multivariable Optimization Techniques: Random search method, Steepest descent method, Conjugate gradient method, Variable metric method. Newton Raphson Method, Evolutionary search, Hooke-Jeeves Method, Simplex search Method

Constrained Optimization Techniques: Interior Penalty function method, Exterior penalty function method, Method of Multipliers, KKT Conditions

FURTHER TOPICS IN OPTIMIZATION: Critical path method (CPM), Program evaluation and review technique (PERT). Multiobjective Optimization Techniques, Weighting method, ε-constraint method. Simulated annealing method

BOOKS RECOMMENDED:

1.   Rao, S.S.,*'Optimization : Theory and Application' Wiley Eastern Press, 2nd edition 1984.*

2.   Deb Kalyanmoy,.*Optimisation for Engineering Design-Algorithms and Examples.,* Prentice Hall India-1998

3.   Taha,H.A., *Operations Research -An Introduction,Prentice Hall of India,2003.*

4.   Fox, R.L., *'Optimization methods for Engineering Design', Addition Welsey, 1971.*

5.   Ravindran A., Ragsdell K.M. and Reklaitis G.V. *, Engineering Optimization: Methods And applications , Wiley, 2008*

6.   *Godfrey C. Onwubolu , B. V. Babu , New optimization techniques in engineering , Springer, 2004*

MTEE-301A ENERGY EFFICIENT MACHINES

			L	**T**	**P**
Internal Marks:	40		3	1	0
External Marks:	60				
Total Marks:	100				

INTRODUCTION: Energy efficient machines, energy cost and two part tariff, energy conservation in industries and agricultural sector -a necessity, introduction to energy management and energy audit system. Review of induction motor characteristics.

ENERGY EFFICIENT MOTORS: Standard motor efficiency, energy efficient motor, efficiency determination methods, Direct Measurement method, Loss segregation method, Comparison, motor efficiency labeling, energy efficient motor standards.

POWER FACTOR: The power factor in sinusoidal systems, power factor improvement, power factor with nonlinear loads, Harmonics and the power factor

APPLICATION OF ELECTRIC MOTORS: Varying duty applications, Voltage variation, Voltage Unbalance, over motoring, Poly-phase induction motors supplied by adjustable frequency power supplies.

INDUCTION MOTORS AND ADJUSTABLE DRIVE SYSTEMS: Energy Conservation, adjustable speed systems, Application of adjustable speed systems to fans, pumps and constant torque loads.

ECONOMICS OF ENERGY EFFICIENT MOTORS AND SYSTEMS: Motor life cycle, Direct Savings and pay back analysis, efficiency evaluation factor, present worth method with constant power costs, present worth method with increasing power costs, net present worth method.

BOOKS RECOMMENDED:

1.   Andreas John C., *Energy efficient electric motors*, Marcel Dekker Inc. 1992.

2.   Thuman Albert, *Introduction to Efficient Electric System Design*, The Fairmount Press Prentice Hall.

3.   Tripathi S.C. , *Electric Energy Utilization and Conservation*, Tata McGraw-Hill 1991.

4.   Belove Charles, *Handbook of Modem Electronics and Electrical Engineering*, John Wiley and Sons.

MTEE-301B POWER SYSTEM DYNAMICS and STABILITY

			L	**T**	**P**
Internal Marks:	40		3	1	0
External Marks:	60				
Total Marks:	100				

OVERVIEW: Angular Stability, Transient stability, steady state stability, dynamic stability, Small Signal, Voltage Stability

MODELING OF POWER SYSTEM COMPONENTS: Generators (Non-linear and linear models using d-q transformation, power capability curve); Excitation System (IEEE standard models); Turbine and Speed governing System; Loads (Induction motors and composite loads);

TRANSIENT STABILITY ANALYSIS: Single Machine - Infinite Bus System; Equal Area Criterion; Multi-machine Stability; Network Reduction and Numerical Integration Methods; Methods of Improvement

SMALL SIGNAL STABILITY ANALYSIS: Eigen Value and Participation Factor Analysis; Single machine - Infinite Bus and Multimachine Simulation; Effect of Excitation System and AVR; Improvement of Damping - Power System Stabilizer and SVS supplementary controls.

SUB SYNCHRONOUS OSCILLATIONS: Sub Synchronous Resonance (SSR) Phenomenon; Counter measures to SSR problems

VOLTAGE STABILITY: P-V and Q-V curves, Impact of Load and Tap-changer Dynamics; Static Analysis, Sensitivity and Continuation Methods; Dynamic Simulation, Introduction to Bifurcation Analysis; Proximity Indices, Methods to enhance Stability Margin.

BOOKS RECOMMENDED:

1. Kundur P, *Power System Stability and Control*, McGraw Hill.

2. Taylor C.W., *Power System Voltage Stability*, McGraw Hill.

3. Anderson P.M. and Foud A. A., *Power System Control and Stability*, IEEE Press.

4. Kimbark E., *Power System Stability*, Vol. I, II and III, IEEE Press.

2

MTEE-301C EHVAC AND HVDC TRANSMISSION SYSTEM

			L	**T**	**P**
Internal Marks:	40		3	1	0
External Marks:	60				
Total Marks:	100				

OVERVIEW: Comparison of EHV AC and DC transmission, description of DC transmission systems, modern trends in AC and DC transmission.

EHV AC SYSTEMS: Limitations of extra-long AC transmission, Voltage profile and voltage gradient of conductor, Electrostatic field of transmission line, Reactive Power planning and control, traveling and standing waves, EHV cable transmission system.

STATIC VAR SYSTEM: Reactive VAR requirements, Static VAR systems, SVC in power systems, design concepts and analysis for system dynamic performance, voltage support, damping and reactive support.

HVDC SYSTEM: Converter configurations and their characteristics, DC link control, converter control characteristics; Monopolar operation, converter with and without overlap, smoothing reactors, transients in DC line, converter faults and protection, HVDC Breakers.

CORONA AND INTERFERENCE: Corona and corona loss due to EHV AC and HVDC, Radio and TV interference due to EHV AC and HVDC systems, methods to reduce noise, radio and TV interference.

HARMONIC FILTERS: Generation of harmonics, design of AC filters, DC filters.

POWER FLOW ANALYSIS IN AC/DC SYSTEMS: Component models, solution of DC load flow, per unit system for DC quantities, solution techniques of AC-DC power flow equations, Parallel operation of HVDC/AC systems, Multi terminal systems.

BOOKS RECOMMENDED:

1. Padiyar K.R., *HVDC Power Transmission Systems*, Wiley Eastern Ltd., New Delhi.

2. Kimbark E., *Direct Current Transmission*, Vol-I, John-Wiley and sons, NY

3. Arrillaga J., *HVDC Transmission*, IEE Press, London.

4. Begamudre R.D., *EHV AC Transmission Engineering*, Wiley Eastern Press.

5. Arrillaga J. and Smith B.C., *AC-DC Power System Analysis*, IEE Press, London.

MTEE-301D POWER SYSTEM TRANSIENTS

Internal Marks: 40   **L   T   P**
External Marks: 60   **3   1   0**
Total Marks: 100

ORIGIN AND NATURE OF TRANSIENTS AND SURGES: Surge parameters of plant. Equivalent circuit representations. Lumped and distributed circuit transients.

LINE ENERGIZATION AND DE-ENERGIZATION TRANSIENTS: Earth and earth wire effects. Current chopping in circuit breakers. Short line fault condition and its relation to circuit breaker duty. Trapped charge effects. Effect of source and source representation in short line fault studies. Control of transients.

LIGHTNING PHENOMENON: Influence of tower footing resistance and earth resistance. Traveling waves in distributed parameter multi-conductor lines, parameters as a function of frequency. Simulation of surge diverters in transient analysis. Influence of pole opening and pole re-closing.

INSULATION CO-ORDINATION: Over voltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs, and metallic contacts.

COMMUNICATION LINKS: PLCC, Microwave, Telephone line, Satellite, Fibre optic. Requirements of' various communication equipments used in power systems. Computer networking in power systems.

BOOKS RECOMMENDED:

1.   Vanikov V.A., *Transients in Power System*, Mir Publications, Moscow.

2.   Bewley; L.V., *Traveling Waves on Transmission Lines*, Dover Publications Inc., New York.

3.   Arora Ravindera and Mosch Wolfgang, *High Voltage Insulation Engineering*, New Age International Publishers Limited.

4.   Greenwood A., *Electrical Transients in Power Systems*, John Wiley & Sons,

5.   Stallings William , *Data and Computer Communication* , PHI, 1994.

6.   Gowar John, *Optical Communications Systems* , PHI, 1993.

7.   R.E. Collin ,*Foundations of Microwave Engineering*.

8.   Theodore S. Rappaport, *Wireless communication, Principles and Practice*, IEEE Press; PTR 1996

MTEE-302A POWER SYSTEM RELIABILITY

				L	T	P
Internal Marks:	40			3	1	0
External Marks:	60					
Total Marks:	100					

PROBABILITY AND RELIABILITY: Review of probability concepts, probability distributions, applications of binomial distribution to engineering problems, probability distribution in reliability evaluation, reliability indices, network modeling and evaluation of simple and complex networks, system reliability evaluation using probability distributions, frequency and load duration techniques, key indices of power system reliability and their calculations.

GENERATION SYSTEM RELIABILITY EVALUATION: Concept of loss of load probability (LOLP), Energy demand, EDNS (Energy demand not served), Evaluation of these indices for isolated systems, generation system, reliability analysis using the frequency and duration techniques.

TRANSMISSION SYSTEM RELIABILITY EVALUATION: Evaluation of LOLP and EDNS, indices for an isolated transmission system, interconnected system reliability, bulk power system reliability.

DISTRIBUTION SYSTEM RELIABILITY EVALUATION: Reliability analysis of radial systems with switching.

BOOKS RECOMMENDED:

1. Billinton R., *Power System Reliability Calculation*, MIT Press, USA.

2. Endreyni, *Reliability Modeling in Electric Power System*, John Wiley, New York

MTEE-302B POWER SYSTEM PLANNING

				L	**T**	**P**
Internal Marks:	40					
External Marks:	60			**3**	**1**	**0**
Total Marks:	100					

INTRODUCTION: Power System planning, objective, stages in planning and design, Key indices of power system reliability and their calculations, Linkage between reliability and capacity planning.

GENERATING SYSTEM CAPABILITY PLANNING: Probabilistic models of generating units, growth rate, Rate of generation capacity, Outage performance and system evaluation of loss of load and loss of energy indices, Power supply availability assessment.

INTERCONNECTED SYSTEMS: Multi area reliability analysis, Power pool operation and power exchange energy contracts, quantification of economic and reliability benefits of pool operation.

DEMAND/ENERGY FORECASTING: Electricity consumption pattern, Peak demand and energy forecasting by trend and economic projection methods.

POWER SYSTEM EXPANSION PLANNING: Formulation of least cost optimization problem involving capital, operation and maintenance costs of candidate units of different types.

INVESTMENT PLANNING MODELS: Traditional generation expansion planning models, integrated resource planning models, production cost simulation models.

BOOKS RECOMMENDED:

1. Wallach Y., *Power System Planning*, McGraw Hill International.

2. Sullivan P., *Power System Planning*, McGraw Hill International.

3. Dasari, S., *Electric Power System Planning*, IBT Publishers, New Delhi.

4. Billinton R., *Power System Reliability Calculation*, MIT Press, USA.

5. Endreyni, *Reliability Modeling in Electric Power System*, John Wiley, New York.

6. McDonald J.R., *Modern Power system Planning*, McGraw Hill International.

MTEE-302C LOAD AND ENERGY MANAGEMENT

Internal Marks:	40		**L**	**T**	**P**
External Marks:	60		**3**	**1**	**0**
Total Marks:	100				

LOAD FORECASTING: Classification and characterization of loads, Approaches to load forecasting, Forecasting methodology, Energy forecasting, Peak demand forecasting, Non-weather sensitive forecast and Weather sensitive forecast, Total forecast, Annual and monthly peak demand forecasts. Applications of state estimation to load forecasting.

LOAD MANAGEMENT: Introduction to Load management. Electric energy production and delivery system structure (EEPDS). Design alternatives for EEPD systems. Communication/control techniques for load management. Tariff structure and load management, principles of macro and microeconomics and energy pricing strategies, Assessing the impacts of load management.

ENERGY DEMAND FORECASTING: Static and dynamic analysis of energy demand, elements of energy demand forecasting, methodologies and models for energy demand forecasting, techno-economic approach in energy demand forecasting.

TRENDS AND CASE STUDIES: Energy management strategy, symbiotic relation between information, energy models and decision making, case studies like industrial energy forecasting, transportation energy forecasting, residential, commercial and agricultural energy forecasting.

BOOKS RECOMMENDED:

1. Martino J., *Technological Forecasting for Decision Making*, Elsevier Press, New York.

2. Gellings C.W. and Penn Well P.E., *Demand Forecasting in the Electric Utility Industry*, Fairmount Press.

3. Makridakis S., *Forecasting Methods and Applications*, Wiley.

MTEE-302D ORGANIZATION AND FINANCE IN POWER SECTOR

			L	T	P
Internal Marks:	40		3	1	0
External Marks:	60				
Total Marks:	100				

MANAGEMENT AND ITS GOALS: Organization and Management; The management process; Managerial skills and Managerial performance; Policy and Objectives of a Power Utility; The Goal of a Firm.

UTILITY FINANCIAL ACCOUNTING: Balance Sheet, Income Statements and Cash Report; Depreciation; Interest charges during construction; Financial Statement Analysis.

INVESTMENT PROPOSAL: Interest and compounding; Measure of price - public versus private perspective; Economic evaluation of investment proposal; Internal Rate of return, Pay-Back Period

LEVELIZED COSTS OF GENERATION: Generating system costs; Basic concept of cost levelization; Levelized bus bar cost.

ELECTRICITY TARIFFS: Traditional Approach; Long-run Marginal costs; General Principles of Tariff Construction; Objectives of tariff.

UTILITY ORGANIZATION: Functional structure; Divisional Structure; Matrix structure; Hybrid structure.

INDUSTRY STATUS AND TRENDS: Main concerns of electric utilities; Performance of electric utilities; Power Sector changes; Dynamic, spot and real time pricing; Regulatory aspects - towards deregulation; System Planning under Evolving Utility Structures Computerized Management Game.

BOOKS RECOMMENDED:

1. Bartol K. M. and David C., *Management*, Martin McGraw-Hill, INC.

2. Bartol K. M. and David C., *Management*, Martin McGraw-Hill, INC.

3. Weston J.F., *Brigham Essential of Managerial* Finance, Dryden Press.

4. Stoll, *Least-Cost Electric Utility Planning*, John Wiley.

5. Stickney C.P. and Weil R.L., *Financial Accounting*, Dryden Press.

6. Berrie T.W., *Electricity Economics and Planning*, IEE Power Series.

7. Levy H. and Sarnat M., *Capital Investment and Financial Decisions*, Prentice Hall.