GURU NANAK DEV ENGNINEERING COLLEGE, LUDHIANA
ELECTRICAL ENGINEERING DEPARTMENT
SYLLABUS SCHEME FOR M.TECH. (POWER ENGG.) FULL-TIME
2014 ONWARDS

Sr. No.	Description of Subject	No. of Subjects	Credits per Subject	Total Credits
1	Core	6	4	24
2	Program Elective (Department Elective)	4	3	12
3	Program Elective (Open Elective)	2	3	6
4	Laboratory	2	2	4
5	Pre Thesis Seminar	1	4	4
6	Pre Thesis Project	1	4	4
7	Thesis	1	14	14
G. Total				68

Sr. No.	Subject Code	Subject Name	Description of Subject	Credits
SEMESTER – I				
1	MTPEE – 501	Advanced Power System Analysis	Core	4
2	MTPEE – 502	Power System Operation and Control	Core	4
3	MTPEE – 503	Advanced Electrical Machines	Core	4
4	MTPEE – 507	Power System Software Lab	Core	2
5	MTPEE – XXX	Department Elective - I	Program Elective	3
6	MTPEE – XXX	Department Elective - II	Program Elective	3
Total Credit				20
SEMESTER – II				
1	MTPEE – 504	HVDC Transmission	Core	4
2	MTPEE – 505	Power System Protection	Core	4
3	MTPEE – 506	EHVAC Transmission	Core	4
4	MTPEE – 508	Industrial Automation Lab	Core	2
5	MTPEE – XXX	Department Elective - III	Program Elective	3
6	MTXX – XXX	Open Elective - I	Program Elective.	3
Total Credit				20
SEMESTER – III				
1	MTPEE – XXX	Department Elective - IV	Program Elective	3
2	MTXX – XXX	Open Elective - II	Program Elective	3
3	MTPEE – 509	Pre Thesis Seminar	Core	4
4	MTPEE – 510	Pre Thesis Project	Core	4
Total Credit				14
SEMESTER – IV				
1	MTPEE – 511	Thesis	Core	14

GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA

ELECTRICAL ENGINEERING DEPARTMENT

MASTER OF TECHNOLOGY (FULL-TIME) POWER ENGINEERING COURSE SUBJECTS (2014 ONWARDS)						
Sr. No.	**Subject code**	**Course title**	**Type**	**L**	**P**	**Credits**
1	MTPEE – 501	Advanced Power System Analysis	Core	4	-	4
2	MTPEE – 502	Power System Operation and Control	Core	4	-	4
3	MTPEE – 503	Advanced Electrical Machines	Core	4	-	4
4	MTPEE – 504	HVDC Transmission	Core	4	-	4
5	MTPEE – 505	Power System Protection	Core	4	-	4
6	MTPEE – 506	EHVAC Transmission	Core	4	-	4
7	MTPEE – 507	Power System Software Lab - I	Core	-	2	2
8	MTPEE – 508	Industrial Automation Lab - II	Core	-	2	2
9	MTPEE – 509	Pre Thesis Seminar	Core	-	2	4
10	MTPEE – 510	Pre Thesis Project	Core	-	2	4
11	MTPEE – 511	Thesis	Core	-	-	14
12	MTPEE – 601	Research Methodology	Program Elective	3	-	3
13	MTPEE – 602	Advanced Power Electronics	Program Elective	3	-	3
14	MTPEE – 603	Digital Control System	Program Elective	3	-	3
15	MTPEE – 604	Energy Efficient Machines	Program Elective	3	-	3
16	MTPEE – 605	Power System Planning	Program Elective	3	-	3
17	MTPEE – 606	Power Systems Stability	Program Elective	3	-	3
18	MTPEE – 607	Advanced Electrical Drives	Program Elective	3	-	3
19	MTPEE – 608	Microprocessors & their applications	Program Elective	3	-	3
20	MTPEE – 609	Industrial Instrumentation and Process Control	Program Elective	3	-	3
21	MTPEE – 610	Power System Transients	Program Elective	3	-	3
22	MTPEE – 611	Operation and Modeling of Restructured Power System	Program Elective	3	-	3
23	MTPEE – 612	Power System Reliability	Program Elective	3	-	3
24	MTPEE – 613	Renewable Energy Resources	Program Elective	3	-	3
25	MTPEE – 614	Reliability Engineering	Program Elective	3	-	3
26	MTPEE – 615	Optimization Techniques	Program Elective	3	-	3
27	MTPEE – 616	Neural Networks & Fuzzy Logic	Program Elective	3	-	3
28	MTPEE – 617	Economics and Organization of Power Sector	Program Elective	3	-	3

MTPEE – 501 ADVANCED POWER SYSTEM ANALYSIS

L: 4	**Marks**	**Hrs.**
End Sem. Exam.	100	03
Internal Assessment	50	**

1. FROMATION OF NETWORK MATRICES & TRANSFORMATION

Incidence and network matrices, formation of network matrices by singular and non-singular transformation.

2. FORMATION OF BUS IMPEDANCE MATRICES

Formation of single phase bus impedance matrix using algorithmic approach including the effect of mutually coupled elements.

3. POWER FLOW ANALYSIS

Review of power flow without and with tap changing and phase shifting transformers, power flow analysis with series and shunt compensating devices, power flow for radial distribution network.

4. OPTIMAL POWER FLOW

Optimal power flow problem formulation and solution techniques.

5. POWER SYSTEM SECURITY

Factors effecting power system security, short circuit and contingency analysis, network sensitivity using load flow, correcting the generation dispatch by using sensitivity method and linear programming.

6. STATE ESTIMATION

State estimation from on line measurements, method of least squares, the line power flow state estimation.

BOOKS RECOMMENDED

1. G.N. Stagg and A. H.EI- Abiad, *Computer Methods in Power System Analysis*, McGraw – Hill, International Edition.
2. George L .Kusic, *Computer Aided Power Systems Analysis*, Prentice Hall.
3. Arrillaga, C.P. Arnold and S.J.Harker, *Computer Modelling of Electrical*
4. John Willey and Sons *Power Systems,*.
5. O.I. Elgerd, *Electric Energy Systems -An Introduction*, Tata McGraw Hill.
6. M.A. Pai, *Computer Techniques in Power Systems Analysis*, Tata McGraw Hill.
7. P.M. Anderson, *Analysis of Faulted Power System*, IEEE Press Book.
8. Related IEEE/IEE Publication.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE – 502 POWER SYSTEM OPERATIONS AND CONTROL

L: 4	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. CHARACTERISTICS OF POWER GENERATION UNITS

Characteristics of steam units, variation in steam unit characteristics, cogeneration plants, hydroelectric units.

2. ECONOMIC DISPATCH OF THERMAL UNITS

Economic Dispatch Problem, Thermal dispatching with network losses considered, penalty factors , lambda iteration method , Gradient method, Newton's method , Dynamic Programming, Base point and participation factors.

3. UNIT COMMITMENT & SOLUTION METHODS

Economic Dispatch v/s unit commitment, constraints in unit commitment, priority method, dynamic programming, analytical method, introduction to optimal power dispatch considering unit commitment.

4. 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.

5. AUTOMATIC GENERATION CONTROL

Generator, Prime mover, Governor, Tie line and load models, Load frequency control, Load frequency and economic dispatch control, Automatic voltage Control, Load frequency control with generation rate constraints, Decentralized control.

6. INTERCHANGE OF POWER AND ENERGY

Economy Interchange between Inter connected utilities, Inter utility Economy Energy Evaluation , Capacity Interchange, Diversity Interchange, Energy Banking, Emergency Power Interchange, Power pools, Transmission Effects and Issues.

BOOKS RECOMMENDED

1. Allen J. Wood and Brace F Woollenberg, *Power Generation Operation and Control*, John Willey & Sons 2nd Edition.

2. D.P. Kothari and J.S.Dhillon, *Power System Optimization*, Prentice-Hall of India, Pvt. Ltd,. New Delhi

3. L.K .Kirchmayer, *Economic Operation of Power Systems*, John Willey & Sons, N.Y.

4. D.P. Kothari and I.J. Nagrath, *Modern Power System Analysis*, Tata McGraw- Hill Publishing Company Ltd., New Delhi.

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MTPEE – 503 ADVANCED ELECTRICAL MACHINES

L: 4	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. POLYPHASE SYNCHRONOUS MACHINES

Mathematical: Basic Synchronous machine parameters, Voltage, Flux linkage and inductance relations, Park's transformation – its physical concept, equations of performance.

2. BALANCED STEADY STATE ANALYSIS

Phasor equations and phasor diagrams, Power-angle characteristics, cylindrical rotor and Salient pole machines, Short circuit ratio.

3. TRANSIENT ANALYSIS & MACHINE DYNAMICS

Three phase short-circuits, Armature and field transients, Transient torque, Sudden reactive loading and Unloading. Transient Analysis-a qualitative approach, Reactance and Time -Constants from equivalent circuits, Measurement of reactance, Transient Power-angle characteristics, The basic electromechanical equation, Linearized Analysis, Large Angular/oscillation, Non-linear analysis.

4. TRANSFORMERS & ITS TRANSIENTS

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

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

5. EXCITATION PHENOMENA IN TRANSFORMERS

Harmonics in Single – phase transformers, Harmonics in three-phase transformers, Disadvantages of harmonics, Suppression of harmonics.

6. 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. Kim bark , *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.

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2. Five questions are to be attempted.

MTPEE – 504 HVDC TRANSMISSION

L: 4	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. HVDC TRANSMISSION & LINKS

Introduction, Comparison, merits and demerits of H.V.D.C. over E.H.V.A.C., types of HVDC links, equivalent Circuit of HVDC link, Basic means of control of HVDC link, CIA, CEA & CC, control characteristics, combined characteristics of a converter.

2. CONVERTERS

Converter connection, rectifier & inverter waveforms, complete analysis of 3-phase (6 pulses) bridge converter, equations of voltage and current on AC& DC side.

3. COMPENSATION

Need of reactive power compensation, methods of compensation in HVDC substation.

4. HARMONICS

Fundamentals of Harmonics, reason of production and harmonic filters.

5. HVDC MULTI-TERMINAL SYSTEMS

Introduction, schematic representation and applications of multi-terminal HVDC systems.

6. PROTECTIVE SYSTEMS

Faults in converters and HVDC system, protective schemes.

BOOKS RECOMMENDED

1. K.R, Padiyar, *HVDC Power Transmission System*, Wiley Eastern Ltd,1990
2. E.W. Kimbark, *Direct Current TransmissionVol:1* , Wiley Interscience,1971.
3. J. Arrillage, *H.V.D.C. Transmission*, Peter Peregrines,1983.
4. J. Arrillage HVDC et. Al, Computer *Modeling of Electrical Power System*, John Wiley 1993.
5. S. Rao, *EHV-AC and Transmission Engineering Practice*, Khanna Publishers 1990.
6. Related IEEE/IEE Publications.

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MTPEE – 505 POWER SYSTEM PROTECTION

L: 4	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. FUNDAMENTALS OF PROTECTIVE RELAYS

Types of relays, their classifications and theory Phase and amplitude comparators. Static Comparators Computer Applications to protective relaying.

2. TRANSMISSION LINE PROTECTION

Carrier Current Protection, Applications of microwave Channels for protective relaying, Selection of suitable static relaying, scheme for transmission line protection. Performance specifications of distance relays, effect of fault resistance and effects of power swings on operation of relays, Distance relay settings, Requirement of Characteristic for different zeros. Selection of suitable static relaying schemes for transmission lines.

3. GENERATORS AND TRANSFORMERS PROTECTION

CT's and PTs burden and accuracy and their connections. Protection of rotor winding. Miscellaneous protection schemes for generators and transformers, over fluxing protection of transformers.

4. DIFFERENTIAL RELAYS

Operating Characteristics, Restraining Characteristics, Analysis of Electromagnetic and differential Static relays schemes.

5. BUS ZONE PROTECTION

Types of bus bar faults, Protection requirements, protection schemes and modern trend in bus-bar protection.

6. CIRCUIT BREAKERS

Physical stress in circuit breakers, Vacuum circuit breakers, SF6 Circuit breakers Direct current C.B's, Short circuit testing of circuit breakers. Comparison of different types of circuit breakers.

BOOKS RECOMMENDED

1. T.S. Madhava Rao, *Power System Protection (Static Relays)*, Tata McGraw-Hill, 1989.
2. A.R. Van C. Warrington, *Protective Relays*, Chapman and Hall London, 1968.
3. S.K. Basu and S. Chaudhary, *Power System Protection*, Raju Primlan Oxford and IBH Press 1983.
4. Ravindra Nalh M. Chander, *Power System Protection and Switch Gear*, John Wiley Eastern 1989.
5. Sunil S. Rao. *Power System Protection and Switch Gear*, Khanna Publishers 1989.
6. Related IEEE/IEE Publications.

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MTPEE – 506 EHVAC TRANSMISSION

L: 4	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. EHVAC TRANSMISSION TOWERS

Introduction to EHV AC Transmission, tower Configurations, types of self- supporting Lattice towers, flexible and semi flexible towers.

2. TRANMISSION LINE AND RELEVANT PARAMETERS

Thermal rating of lines, temperature rise of conductors and current carrying capacity of lines and cables, corona, corona loss, properties of bundled conductors, average value of line parameters, power handling capacity, selection of cable for EHV AC transmission, electrical characteristics and cable insulating materials.

3. ELECTROSTATIC FIELD OF EHV LINES

Capacitance of long objects under transmission lines, electrostatic field of 3-phase single circuit and double circuit AC lines, biological effects of electrostatic fields.

4. LIGHTNING AND LIGHTNING PROTECTION

Over voltage factors, type of surge arresters, rating and classification of surge arresters based on applications, insulation withstand characteristics of long air gaps.

5. DESIGN ANALYSIS

Voltage stability, design of EHV lines based on steady-state limits, series and shunt compensation, reactive power control apparatus.

6. INTRODUCTION TO FACTS & APPLICATIONS

Introduction to FACT devices: SVC, TCSC, SSSC, STATCOM and UPFC, applications.

BOOKS RECOMMENDED

1. R. D. Begamudre, *EHV* AC Transmission, Wiley Eastern Ltd., 2nd edition.
2. *Transmission Line*, Reference Book: 345 KV and above EPRI, Palo Alto USA.
3. *Electrical Transmission and Distribution*, Reference Book, Oxford book Company, Calcutta.
4. S. Rao, *EHV –AC and HVDC Transmission Engineering*, Practice, Khanna Publishers.
5. Related IEEE/IEE Publications.
6. **FACTS, Hingorani,**

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MTPEE – 507 POWER SYSTEM SOFTWARE LAB – I

P: 2	**Marks**
Viva-voce	50
Internal Assessment	50

Development of algorithms & flowcharts and digital simulation of the following using ETAP/MATLAB Software package:

1. Z-bus and Y-bus formulation
2. Load flow studies
3. Fault analysis
4. Transient stability studies
5. Economic load dispatch

MTPEE – 508 INDUSTRIAL AUTOMATION LAB – II

P: 2	Marks
Viva-voce	50
Internal Assessment	50

1. Programmable Logic Controller (PLC) –General introduction, basic concepts, different types of programming: ladder programming. Instruction List programming, High level programming, flow diagram programming.
2. Simple introductory programs.
3. Use of PLC for: Simple domestic or commercial lighting automation, water level control.
4. Industrial applications of PLC using Timer and Counter Function.
5. Study & use of SCADA Software for different process control systems.

BOOKS RECOMMENDED

1. Control Engg.-by Noel M. Morris.
2. Industrial Electronics-by Thomas E. Kissell, PHI, N. Delhi.

MTPEE – 601 RESEARCH METHODOLOGY

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. 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.

2. 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.

3. DESIGN OF EXPERIMENTS

Basic principles, study of completely randomized and randomized block design. Edition and tabulation of results, presentation of results using figures, tables and text, quoting of references and preparing bibliography. Use of common software 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.

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2. Five questions are to be attempted.

MTEE – 602 ADVANCED POWER ELECTRONICS

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION

Power Electronic Systems, Power Semiconductor switches, Basic electrical and magnetic circuit concepts.

Temperature Control and Heat Sinks: Control of semiconductor device temperatures, Heat transfer by conduction, Heat sinks, Heat transfer by radiation and convection

2. POWER SUPPLY APPLICATIONS

Switching dc Power Supplies: Introduction, Comparison of Linear power supplies and switching power supplies, dc-dc converters with electrical isolation, Control of SMPS, Power supply protection Electrical isolation in the feedback loop, designing to meet power supply specifications. Power Conditioners and Uninterrupted Power Supplies: Introduction, Power line disturbances, Power Conditioners, Uninterrupted Power Supplies (UPS).

3. RESIDENTIAL AND INDUSTRIAL APPLICATIONS

Electric Utility Applications: Introduction, HVDC, Static Var Compensators, Interconnection of Renewable Energy Sources and Energy storage Systems to the Utility Grid.

4. PRACTICAL CONVERTER DESIGN CONSIDERATIONS

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.

5. 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. 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.

Note

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2. Five questions are to be attempted.

MTPEE – 603 DIGITAL CONTROL SYSTEMS

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. OVERVIEW OF DIGITAL CONTROL

Configuration of the basic Digital Control Systems, types of sampling operations, Sample and Hold operations, Sampling theorem, Basic discrete time signals.

2. ANALYSIS OF DIGITAL CONTROL

Z-Transforms, Properties of Z-Transform, Inverse Z-Transforms, Pulse Transfer Function, Difference equations, Z-Transform method for solving the difference equations, Block diagram and signal flow graph analysis, Time response of digital control systems.

3. STABILITY METHODS

Mapping between s-plane and z-plane, stability methods: Modified Routh Criterion Jury's method, modified Schur-Cohn criterion

4. MODELING AND DESIGN OF DIGITAL CONTROL SYSTEMS

Digital temperature control System, Digital position control system, stepping motors and their control, Design of Digital compensator using frequency response plots.

5. STATE VARIABLE ANALYSIS OF DIGITAL CONTROL SYSTEMS

Review of state variable methods, state variable description of digital control systems, conversion of state variable models to pulse transfer function and vice versa, solution of state difference equations, controllability and observability.

BOOKS RECOMMENDED

1. M. Gopal, *Digital Control and State Variable Methods*, Tata McGraw-Hill.
2. K.Ogata, *Discrete Time Control Systems*, Pearson Education, (Singapore) (Thomson Press India)
3. B.C Kuo, *Digital Control Systems*, Prentice Hall.
4. I.J. Nagrath & M.Gopal , *Control System Engg*., John Wiley & sons.
5. K.K. Aggarwal, *Control System Analysis and Design*, Khanna Publisher

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MTPEE-604 ENERGY EFFICIENT MACHINES

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION

Need for energy efficient machines in recent energy scenario, energy conservation and energy auditing in industries, review of types of induction motors and their characteristics, classification of induction motors based on Torque-Slip characteristics, The p.f in sinusoidal systems, p.f improvement.

2. ENERGY EFFICIENT MOTORS

Standard motor efficiency, energy efficient motors, efficiency determination methods, direct measurement method, loss segregation method, comparison, motor efficiency labeling, energy efficient motor standards.

3. APPLICATION OF ELECTRIC MOTORS

Varying duty applications, voltage variation, voltage unbalance, over motoring, poly-phase induction motors supplied by adjustable frequency power supplies.

4. ADJUSTABLE DRIVE SYSTEMS

Adjustable speed systems, Application of adjustable speed systems to fans, pumps and constant torque loads.

5. ECONOMICS OF ENERGY EFFICIENT MOTORS

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

2. Thuman A., *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 C., *Handbook of Modern Electronics and Electrical Engineering*, John Wiley & Sons.

5. Gupta B.R., *Generation of Electric Power*, S Chand Publishers, 2009.

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MTPEE – 605 POWER SYSTEM PLANNING

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. POWER SYSTEM PLANNING & RELIABILITY

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

2. 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.

3. INTERCONNECTED SYSTEMS

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

4. LOAD FORECASTING & EXPANSION PLANNING

Electricity consumption pattern, Peak demand and energy forecasting by trend and economic projection methods, formulation of least cost optimization problem involving capital, operation and maintenance costs of candidate units of different types.

5. INVESTMENT PLANNING MODELS

Traditional generation expansion planning models, integrated resource planning models, production cost simulation models. Load characteristics, Design of sub transmission lines and distribution, substations, Design considerations of' primary and secondary distribution systems, Voltage drop and power loss calculations, Distribution system, voltage regulation, application of capacitors to distribution systems.

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

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MTPEE – 606 POWER SYSTEM STABILITY

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. 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).

2. TRANSIENT STABILITY ANALYSIS

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

3. SMALL SIGNAL STABILITY ANALYSIS

Eigen Value and Participation Factor Analysis; Single machine - Infinite Bus and Multi-machine Simulation; Effect of Excitation System and AVR; Improvement of Damping - Power System Stabilizer and SVS supplementary controls.

4. SUB SYNCHRONOUS OSCILLATIONS

Sub Synchronous Resonance (SSR) Phenomenon; Counter measures to SSR problems.

5. 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.

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MTPEE - 607 ADVANCED ELECTRICAL DRIVES

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION

Definition, Types of loads, steady state & transient stability of a drive, state of art of power electronics and drives, selection of motor rating.

2. D.C. DRIVES

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

3. INDUCTION MOTOR DRIVES

Introduction, Induction motor Characteristics at rated (Line) frequency and rated voltage, Speed control by varying stator frequency and voltage, Impact of Non sinusoidal excitation on Induction Motors, Variable frequency Converter classifications, Variable frequency PWM-VSI drives, Variable frequency Square Wave VSI drives, Variable frequency CSI drives, Comparison of Variable-Frequency Drives, Line frequency variable voltage drives Reduced voltage starting ("Soft Start") of Induction Motors, Speed control by static slip power recovery. Mathematical modeling of induction motor drives, transient response and stability analysis

4. SYNCHRONOUS MOTOR DRIVES

Adjustable frequency operation, voltage fed drive, current fed self-controlled drive.

5. AUTOMATION USING DRIVES

Sensor less vector control and Direct Torque Control 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*
6. Ned Mohan, *Power Electronics: Converters Applications and Design*, Wiley India Edition.
7. Related IEEE/IEE Publications.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE – 608 MICROPROCESSORS AND THEIR APPLICATIONS

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. MICROPROCESSOR

Intel 8085- Introduction, register structure, memory Addressing, Addressing Modes, Instruction Set, Timing Methods, CPU Pins and Associated Signals, Instruction timing and execution. Programming I/O. Interrupt System, DMA, SID & SOD lines, Instruction set, 8085 based system design. Intel 8086–Introduction, Architecture, Addressing modes, instruction set, memory management, assembler dependent instructions, Input/output, system design using 8086.

2. PROGRAMMING OF 8086 PERIPHERAL INTERFACING

Parallel versus serial transmission, synchronous and asynchronous serial data transmission. Interfacing or hexadecimal keyboard and display unit, interfacing of cassette recorders and parallel, serial interface standards

3. MICROPROCESSOR APPLICATIONS TO POWER ENGINEERING

Speed control of motors, p.f. control, numerical relay control and heat control, programming of numerical relay.

4. PROTECTIVE RELAYING

Over-current, impedance, MHO, reactance, bi-directional relays.

5. MEASUREMENTS

Frequency, power angle & power factor, Voltage and Current, KVA, KW, KVAR, maximum demand. Resistance, Reactance, Temperature Controls.

BOOKS RECOMMENDED

1. Rafiquzzaman, *M. Theory and Applications*, Prentice Hall (India) Publications 1993
2. Ram B, *Fundamentals of Microprocessors and Microcomputers*, Dhanpat Rai and Sons,
3. Gaonkar R.S., *Microprocessor Architecture, Programming and Applications* John Wiley 1989.
4. Cheng L.Y., Gibson, G.A.PHI 1992.
5. Leventhal, L.A., *Introduction to Microprocessors: Software, Hardware, Programming.*
6. RelatedIEEE/IEEPublications.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE – 609 INDUSTRIAL INSTRUMENTATION AND PROCESS CONTROL

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION

Introduction to sensors and measurement systems, Static and Dynamic response of a transducer system, estimation of errors and calibrations transducers and sensors; their characteristics and parameters.

2. TRANSDUCERS

Strain gauge, load cell, LVDT, capacitive transducers, Piezoelectric transducers, Ultrasonic transducers, Measurement of temperature viz; thermistor, thermocouple, RTD and problems related to temperature sensors, Measurement of pressure, flow, pH, torque and viscosity. Problems and solutions on industrial automation.

3. SIGNAL CONDITIONING CIRCUITS

Introduction to process control, architecture of industrial automation systems.

4. PID CONTROLLERS

P, PI and PID control controller tuning, implementation of PID controllers.

5. CONTROL AND INDUSTRIAL AUTOMATION

Role of instrumentation in monitoring, control and industrial automation special control structures: feed forward and ratio control, predictive control, control of system with inverse responses, cascade control, overriding control, selective control and split range control.

BOOKS RECOMMENDED

1. Ernest O Doeblin, Measurement Systems, Mc-Graw Hill.
2. W.D. Coopper & A.D. Helfrick, Electronic Instrumentation and Measurement Techniques, PHI.
3. B.C. Nakra and K.K. Choudhary, Instrumentation Measurement Analysis, Tata McGraw-Hill.
4. Instrumentation systems by Mani Sharma, Rangan.
5. RelatedIEEE/IEEPublications.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE – 610 POWER SYSTEMS TRANSIENTS

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION TO TRANSIENTS

Origin and nature of power system Transients, Traveling waves on transmission system, the line equation. The shape attenuation and distortion of waves, reflection of traveling waves, Successive ref1ections, Traveling waves on multi-conductor systems. Transition points on multi conductor circuits.

2. THEORY OF GROUND WIRES

Direct Stroke to a tower, Effect of reflection up and down the tower, the counterpoise.

3. SWITCHING SURGES & LIGHTENING

Switching Surge: Normal frequency effects, High charging currents, cancellation waves, Recovery voltage, Restricting phenomena.

Lightening: Charge formation, mechanism of lightening stroke, mathematical model of lightening stroke.

4. PROTECTION

Protection of transmission systems against surge.

5. FREQUENCY

High frequency oscillations and terminal transients of transformer.

BOOKS RECOMMENDED

1. Bewley L.V., *Traveling waves on transmission systems, power*, Publication lnc New York, 1963.
2. Rudenterg R., *Electric Stroke waves in Power Systems*, Harvard University Press, Cambridge, Massachusetts, 1968.
3. Wood A.G., *Electrical Transients in Power Systems*, Wiley lnterscience, 1971.
4. EPRI, *Transmission Line*, Reference Book 345KVand above, 1984.
5. *Surge Protection in Power Systems*. IEEE Publication, 79EHD 144-46PWR.
6. Regaller K., *Surges in High Voltage Networks*, Plenum Press, 1980.
7. Related IEEE/IEE Publications.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE - 611 OPERATION AND MODELING OF RESTRUCTURED POWER SYSTEM

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION

Overview of restructured power system, difference between vertically integrated and restructured power systems, advantages of competitive environment in power system, components of restructured power system, restructuring models, transmission open access, national and international scenarios.

2. MARKET DISPATCH

DC and AC optimal power flow formulations, generation and demand bidding, social welfare, market dispatch for social welfare maximization, shadow prices, locational marginal pricing and its components

3. TRANSMISSION CONGESTION MANAGEMENT

Transmission congestion problem, market power, congestion management methodologies, preventive and corrective congestion management approaches, rescheduling and load auctions.

4. AVAILABLE TRANSFER CAPABILITY

Introduction, definition, principles of ATC determination, methods of static ATC determination.

5. TRANSMISSION PRICING AND WHEELING

Definition and scope, cost components of transmission system, MW-mile and MVA-mile methodologies, proportionality sharing principle, loss modeling, transmission pricing in India.

BOOKS & RESEARCH PAPERS RECOMMENDED

1. Loi Lei Lai, Power *system restructuring and deregulation*, John Wiley & Sons Ltd.

2. P. Venkatesh, B.V. Manikandan, S. Charles Raja, and A. Srinivasan, "*Electric Power Systems, Analysis, Security and Deregulation*, PHI Learning Pvt. Ltd., New Delhi.

3. Lorrin Philipson and H. Lee Willis, Marcel Dekker, *Understanding electric utilities and deregulation*, New York, CRC Press, 2005.

4. Marija Ilic, Francisco Galiana and Lestor Fink, *Power system restructuring engineering & economics*, Kulwer Academic Publisher, USA-2000.

5. Santoso Surya, Beaty H. Wayne, Dugan Roger C., McGranaghan Mark F., *Electric power system quality*, McGraw Hills, 2002.

6. R.D. Christie, B.F. Wollenberg, and I. Wangensteen, "*Transmission management in the deregulated environment*," Proc. of the IEEE, vol. 88, no. 2, pp. 170-195, Feb. 2000.

7. A. Kumar, S.C. Srivastava, and S.N. Singh, "*A Zonal Congestion Management Approach Using Real and Reactive Power Rescheduling*," IEEE Trans. Power Syst., vol. 19, no. 1, pp. 554-562, Feb. 2004.

8. L.A. Tuan, K. Bhattacharya, and J. Daalder, "*Transmission congestion management in bilateral markets: An interruptible load auction solution*," Elect. Power Syst. Res., vol. 74, no. 3, pp. 379-389, Jun. 2005.

9. A.J. Conejo, J. Contreras, D.A. Lima, and A.P. Feltrin, "*Zbus Transmission Network Cost Allocation*," IEEE Trans. Power Syst., vol.22, no.1, pp.342-349, Feb. 2007.

10. A. R. Abhyankar, S. A. Khaparde, S. A. Soman, P. Pentayya, "*A Transmission Pricing Mechanism Based on Power Tracing for Central Transmission Utility in India*," International Journal of Emerging Electric Power Systems, Volume 2, Issue 1 2005 Article 1033

11. K. Singh, N.P. Padhy, and J. Sharma, "*Influence of Price Responsive Demand Shifting Bidding on Congestion and LMP in Pool-Based Day-Ahead Electricity Markets*," IEEE Trans. Power System, vol. 26, no. 2, pp 886-896, May 2011.

Note

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2. Five questions are to be attempted.

MTPEE – 612 POWER SYSTEM RELIABILITY

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. BASIC RELIABILITYCONCEPTS

The General reliability function, Hazard rate, MTTF, Markov processes.

2. STATIC GENERATING CAPACITY RELIABILITY EVALUATION

Capacity outage probability tables, loss of load probability method, Frequency and duration approach.

3. SPINNING GENERATION CAPACITY RELIABILITY EVALUATION:

Spinning capacity evaluation, Load forecast uncertainty, Derated capacity levels.

4. TRANSMISSION SYSTEM RELIABILITY EVALUATION

Average interruption rate method, Frequency and duration method, Stormy and normal weather effects, The Markov process approach.

5. COMPOSITE SYSTEM RELIABILITY EVALUATION

Conditional probability approach, two–plant single load system.

BOOKS RECOMMENDED

1. Billinton R., *Power System Reliability Calculation*, MIT Press, USA
2. Endreyni, *Reliability Modeling in Electric Power System*, John Wiley, New York

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MTPEE – 613 RENEWABLE ENERGY RESOURCES

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. ENERGY RESOURCES

Renewable energy sources, Energy and Global Climate Change energy parameters, atmospheric aspects of electric energy generation, Impact of renewable energy generation on environment, Electromagnetic Radiation from Extra High Voltage Overhead lines

2. SOLAR, WIND AND GEOTHERMAL ENERGY

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

Wind turbines and rotors, Modes of Wind Power Generation, Estimation of Wind Energy Potential, Selection of Optimum Wind Energy Generator (WEG).

Geothermal Sites, Geothermal Field, Geothermal Resources, Geothermal Electric Power Plant.

3. FUEL CELLS & BIOMASS

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, introduction to biomass as energy source.

4. HYDROGEN ENERGY SYSTEM

Hydrogen Production, Hydrogen Storage, Development of Hydrogen Cartridge, Gas Hydrate.

5. 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 edition, 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 and their 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

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MTPEE – 614 RELIABILITY ENGINEERING

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. RELIABILITY MATHEMATICS

Random experiments, probability, random variables, distribution functions, discrete distributions, Continuous distributions.

2. NETWORK MODELLING AND RELIABILITY EVALUATION OF SIMPLE SYSTEMS

Series systems, parallel system, series-parallel systems, partially redundant systems, standby redundant systems.

3. NETWORKS AND RELIABILITY EVALUATION OF COMPLEX SYSTEMS

Cut set method, Tie-set method, Connection matrix techniques, Event trees, Fault trees.

4. PROBABILITY DISTRIBUTIONS IN RELIABILITY EVALUATION

General reliability function, Poisson distribution, normal distribution, exponential distribution.

5. DISCRETE & CONTINUOS MARKOV CHAINS

General modelling Concept, Stochastic transitional prob. matrix, Time dependent prob. evaluation, limiting state Prob. evaluation, Absorbing States.

General modelling concepts, state space diagrams, Stochastic transitional probability matrix, Evaluating limiting state probabilities.

BOOKS RECOMMENDED

1. Srinath L.S., *Reliability Engineering*, Affiliated East, West Press Pvt. Ltd., New Delhi.
2. Balagurusamy E., *Reliability Engineering*, Tata McGraw Hill Publishing Company Ltd., New Delhi.
3. Billinton R. & Allan R.N., *Reliability Evaluation of Engg. Systems*: *Concepts & Techniques*, Plenum Press, N.Y. and London.

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MTPEE – 615 OPTIMIZATION TECHNIQUES

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. INTRODUCTION TO OPTIMIZATION

Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engg. applications of optimization.

2. CLASSICAL OPTIMIZATION TECHNIQUES

Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with in equality constraints.

3. LINEAR PROGRAMMING &TRANSPORTATION PROBLEM

Standard form of linear programming ,Graphical solution, Simplex method, Two phase simplex method, Computer implementation of the simplex method, Duality theory.
North-West Corner rule, Least cost method, Vogel approximation method, testing for optimality.

4. NON-LINEAR PROGRAMMING: ONE–DIMENSIONAL MINIMIZATION METHODS

Unimodal function, Dichotomous search, Fibonacci search, Quadratic interpolation method, Cubic interpolation method.

5. NON-LINEAR PROGRAMMING-UNCONSTRAINED & CONSTRAINED OPTIMIZATION TECHNIQUES

Random search method, Steepest descent method, Conjugate gradient method, Variable metric method.
Interior Penalty function method, Exterior penalty function 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*

Note

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MTPEE – 616 NEURAL NETWORKS & FUZZY LOGICS

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. NEURAL NETWORK CHARACTERISTICS

History of development in neural networks principles, artificial neural net terminology, Model of a neuron, Topology, Learning, types of learning, Supervised, Unsupervised, Re-enforcement learning. Knowledge representation and acquisition.

2. ALGORITHMS & MODELS

Basic Hop filed model, Basic learning laws, unsupervised learning, Competitive learning, K-means clustering algorithm, Kohonen's feature maps.

3. NEURAL NETWORKS

Radial basis function neural networks, Basic learning laws in RBF nets, Recurrent back propagation, Introduction to counter propagation networks, CMAC network and ART networks.

4. APPLICATIONS

Application of neural networks for electric load and electricity price forecasting, Optimization and decision-making.

5. FUZZY LOGICS

Basic concepts of fuzzy logic, Fuzzy vs. Crisp set, Linguistic variable, Membership functions, Operations of fuzzy sets, Fuzzy IF-THEN rules, Variable inference techniques, De-Fuzzification Basic fuzzy inference algorithm, Fuzzy system design, FKBC & PID control , Antilock Breaking system(ABS), Industrial applications.

BOOKS RECOMMENDED

1. Haykin S., *Neural Networks*.
2. ROSS J.T., *Fuzzy logic with engineering application*
3. Kosko B., *Neural Networks & Fuzzy Logic*.
4. Wasserman P.D., *Neural computing theory & practice,* ANZA PUB.
5. Ibrahim A. M., *Introduction to applied Fuzzy Electronics*, PHI.
6. Zurada J.M., *Introduction to artificial neural systems*, Jaico Pub.
7. Driankor D., Hellendorn H., Reinfrank M., *An Introduction to Fuzzy control*, Narosa Pub.
8. Jnie J., LINKERS D., *Fuzzy Neural Control*,PHI.
9. Related IEEE/IEE Publications.
10. Riza C., Berkiu & Trubatch, *Fuzzy System Design Principles, Buildidng Fuzzy IF-THEN Rule Bases* IEEE Press.

Note

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

MTPEE – 617 ECONOMICS AND ORGANIZATION OF POWER SECTOR

L: 3	Marks	Hrs.
End Sem. Exam.	100	03
Internal Assessment	50	**

1. 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.

2. UTILITY FINANCIAL ACCOUNTING

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

3. INVESTMENT PROPOSAL

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

4. ELECTRICITY TARIFFS

Traditional Approach; Long-run Marginal costs; General Principles of Tariff Construction; Objectives of tariff. Generating system costs; Basic concept of cost levelization; Levelized bus bar cost, spot and real time pricing

5. UTILITY ORGANIZATION

Functional structure; Divisional Structure; Matrix structure; Hybrid structure, main concerns of electric utilities; Performance of electric utilities.

BOOKS RECOMMENDED

1. Bartol K. M. and David C., *Management*, Martin McGraw-Hill, INC.
2. Weston J.F., *Brigham Essential of Managerial* Finance, Dryden Press
3. Stoll, *Least-Cost Electric Utility Planning*, John Wiley.
4. Stickney C.P. and Weil R.L., *Financial Accounting*, Dryden Press
5. Berrie T.W., *Electricity Economics and Planning*, IEE Power Series.
6. Levy H. and Sarnat M., *Capital Investment and Financial Decisions*, Prentice Hall

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