TEACHING SCHEDULE & STUDY SCHEME

M.TECH PROGRAMME

(Power Engineering)

(To be applicable for M. Tech. admission for session July/Aug-2004 and onwards)
Regional Centre of Punjab Technical university, Jalandhar

M. Tech (Power Engg.)

PREAMBLE

There is a need of qualified faculty (Ph. D. and M. Tech) in various fields of Engineering and Technology. Punjab does not have many institutions offering PG Courses in Engineering and Technology. Keeping this fundamental need in mind, the University has ventured in establishing regional centres in strategic locations in the state of Punjab to offer M.Tech and Ph. D. programmes for the teachers in various technical institutions in the state of Punjab.

The scheme of M. Tech (Power Engineering) will consist of 8 Nos. core courses and 4 Nos. Professional (Elective) Courses besides 2 Nos. Lab courses, Project /Seminar and dissertation. The structure of the courses shall be as follows:

<table>
<thead>
<tr>
<th>Semester</th>
<th>No. of Courses</th>
<th>Contact hours per Course per week.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st}</td>
<td>5 Theory Courses+ 01 Lab Course</td>
<td>04</td>
</tr>
<tr>
<td>2\textsuperscript{nd}</td>
<td>3 Compulsory Courses+ 02 Elective Courses*+ 01 Lab Course</td>
<td>04</td>
</tr>
<tr>
<td>3\textsuperscript{rd}</td>
<td>2 Elective Courses** +Project +Seminar</td>
<td>04 04 02</td>
</tr>
<tr>
<td>4\textsuperscript{th}</td>
<td>Dissertation</td>
<td>02 Hrs./Week</td>
</tr>
</tbody>
</table>

* 02 Elective Courses are to be selected from the list of Electives-I & Electives-II:
**02 Elective Courses are to be selected from the list of Electives-III & Electives-IV:

M. Tech (Power Engineering) Degree Shall be of 2200 marks. For project there shall be 50 internal and 50 external marks and Seminar will be of 100 internal marks. There shall be no marks for dissertation and dissertation shall be evaluated as satisfactory/unsatisfactory.
### M. Tech (Power Engineering) Full Time/Part Time

**Course Structure and Scheme of Evaluation**

*(To be effective w.e.f. M.Tech admissions for the session July/Aug-2004 and onwards)*

#### 1st Semester:

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
<th>Hrs/Week</th>
<th>Evaluation (Marks)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internal Marks</td>
<td>External Marks</td>
</tr>
<tr>
<td>PEE-501</td>
<td>Power System Operation &amp; Control</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-502</td>
<td>Advanced Power System Analysis</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-503</td>
<td>Advanced Power Electronics</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-504</td>
<td>Digital Control Systems</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-505</td>
<td>Advanced Electrical Machines</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-506</td>
<td>Power System Software Lab</td>
<td>4</td>
<td>50</td>
<td>50</td>
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</table>

Total Marks = 850

#### 2nd Semester:

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
<th>Hrs/Week</th>
<th>Evaluation (Marks)</th>
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<tr>
<td></td>
<td></td>
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<td>Internal Marks</td>
<td>External Marks</td>
</tr>
<tr>
<td>PEE-507</td>
<td>Advanced Mathematics</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-508</td>
<td>H.V.D.C. Transmission</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-509</td>
<td>Power System Protection</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-510</td>
<td>Industrial Automation Lab</td>
<td>4</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>PEE-</td>
<td>Elective-I</td>
<td>4</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>PEE-</td>
<td>Elective-II</td>
<td>4</td>
<td>50</td>
<td>100</td>
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Total Marks = 850

#### 3rd Semester:

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
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<tbody>
<tr>
<td></td>
<td>Elective –III</td>
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<tr>
<td></td>
<td>Elective-IV</td>
</tr>
<tr>
<td>PEE-511</td>
<td>Project</td>
</tr>
<tr>
<td>PEE-512</td>
<td>Seminar</td>
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Total Marks = 500

#### 4th Semester:

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
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<tbody>
<tr>
<td>PEE-600</td>
<td>Dissertation</td>
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|          |                  |
# LIST OF ELECTIVE COURSES

## ELECTIVE-I

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hrs/Week</th>
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<th>Ext. Marks</th>
<th>Total</th>
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<tbody>
<tr>
<td>PEE-513</td>
<td>Power Systems Stability</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-514</td>
<td>E.H.V.A.C. Transmission</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-515</td>
<td>Reliability Engg.</td>
<td>4</td>
<td>50</td>
<td>100</td>
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## ELECTIVE-II

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hrs/Week</th>
<th>Int. Marks</th>
<th>Ext. Marks</th>
<th>Total</th>
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<tbody>
<tr>
<td>PEE-516</td>
<td>Microprocessors and their applications</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-517</td>
<td>Applied Instrumentation</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>PEE-518</td>
<td>Fast Transients in Power Systems</td>
<td>4</td>
<td>50</td>
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## ELECTIVE-III

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Hrs/Week</th>
<th>Int. Marks</th>
<th>Ext. Marks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEE-519</td>
<td>Energy Efficient Machines</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>PEE-520</td>
<td>Advanced Electrical Drives</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-521</td>
<td>Non-Conventional Energy Sources</td>
<td>4</td>
<td>50</td>
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## ELECTIVE-IV

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hrs/Week</th>
<th>Int. Marks</th>
<th>Ext. Marks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEE-522</td>
<td>Power System Reliability</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-523</td>
<td>Power System Planning</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-524</td>
<td>Power System Communication</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>PEE-525</td>
<td>Optimization Techniques</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>PEE-526</td>
<td>Neural Networks &amp; Fuzzy Logic</td>
<td>4</td>
<td>50</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>
1. **Characteristics of Power Generation Units:**
   Characteristics of steam units, variation in steam unit characteristics, cogeneration plants, Hydro electric 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. Economic dispatch vs unit commitment, constraints in unit commitment. Introduction to optimal power flow, Solution of optimal power flow by gradient method.

3. **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.

4. **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.

5. **Interchange of Power and Energy:**

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

**Note:**
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
PEE-502  

**Advanced Power System Analysis**

<table>
<thead>
<tr>
<th>L:4</th>
<th>Marks</th>
<th>Hrs.</th>
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<tbody>
<tr>
<td>Uni. Exam.</td>
<td>100</td>
<td>03</td>
</tr>
<tr>
<td>Sessional</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

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


4. Short circuit calculations using Z-BUS for balanced and unbalanced three phase networks, symmetrical components, sequence impedances, sequence networks, Unbalanced fault analysis for three phase to ground fault, LG fault, LL Fault, LLG Fault.


6. Contingency Analysis for power systems using Brown’s method, State estimation from on line measurements, The line power flow state estimation.

**Books:**


**Note:**

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

L: 4 Marks Hrs.
Uni. Exam. 100 3
Sessional 50

I. Power Semiconductor Diodes:

2. Thyristor:
V -I Characteristics, Turn ON & Turn OFF Characteristics, di/dt and dv/dt protection. Series and Parallel Operation of Thyristors, Thyristor firing circuits, UJT and PUJT, Thyristor commutation Techniques.

3. Power Transistors:
Bipolar Junction Transistors, their steady State & Switching Characteristics, Power MOSFET’S and their steady state & switching characteristics, Gate drive SIT’s & IGBT’S’s, Series & Parallel Operation, di/dt and dv/dt limitations,

4. Controlled Rectifiers:
Single Phase & Three Phase full Converters with R-L load, Single phase & three phase dual converters, Power factor improvement technique.

5. A.C. Voltage Controllers:
Principle of phase control, Single phase and three phase full controllers, Cycloconvertor, A.C. voltage Controllers with PWM Control, Effects of source & Load Inductances

6. D.C Choppers:
Chopper Classification, Thyristor Chopper Circuits, Chopper Circuit Design.

7. PWM Inverters:
Principle of Operation, Performance parameters, single phase bridge invertors and their voltage Control, Harmonic Reduction, Inverter Circuit Design.

Recommended Books:-
1. M.H. Rashid , Power Electronics Circuits Devices application, PHI.1994

Note
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to the attempted.
1. **Introduction:**
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 Systems:**

3. **Stability Methods:**
Mapping between s-plane and z-plane, stability methods: Modified Routh Criterion, Jury’s method, modified Schur-Cohn criterion.

4. **Models of Digital Control Systems:**
Digital temperature control System, Digital position control system, stepping motors and their control.

5. **Design of Digital compensator using frequency response plots.**

6. **Control Systems Analysis Using State Variable Methods:**
State variable representation, conversion of state variable models to transfer function and vice-versa, Eigen values and eigen vectors, Solution of state equations, Concepts of controllability and observability.

7. **State Variable analysis of Digital Control Systems:**
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.

**Recommended Books:**
Note:
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

PEE: 505  Advanced Electrical Machines

L: 4  Marks Hrs.
Univ. Exam. 100  3
Sessional  50

1. Polyphase Synchronous Machines:
   b. Balanced Steady State Analysis: Phasor equations and phasor diagrams, Power-angle characteristics, cylindrical rotor and Salient pole machines, Short circuit ratio.
   d. Synchronous - machine Dynamics: The basic electromechanical equation, Linearized Analysis, Large Angular/oscillation, Non-linear analysis.

2. Transformers:
   c. Transformer Transients: Inrush current phenomena, Qualitative approach, Analytical approach, Inrush current in 3-phase transformers.

Recommended Text Book:
Generalized theory of Electrical Machines by Dr. P.S. Bimbhra ( Khanna Publishers.)

Reference Books:
2. Synchronous machines by Concordia.
4. Electrical Machinery by Fitzegerald, Kingsley.
5. Electrical Machines by A. Draper.
6. Magnetic Circuits and Transformer MIT Staff.
8. Electromagnetic transients by Adkins and Hoffman,

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

### PEE-506 POWER SYSTEM SOFTWARE LAB

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
<th>Hrs/Week</th>
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</thead>
<tbody>
<tr>
<td>Int.</td>
<td>50</td>
<td>04</td>
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<tr>
<td>Ext.</td>
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</tbody>
</table>

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.
Operational Calculus: Laplace Transform, Inverse Laplace Transform, Convolution, z-Transform, Inverse z Transform, Convolution.

Fourier Transform: Properties, convolution, and correlation, Fourier series and sampled waveforms, Discrete Fourier Transform (DFT), discrete convolution and correlation, Fast Fourier Transform (FFT) and its applications. FFT Convolutions and correlation, Two-dimensional FFT Analysis.


Non-linear Ordinary Differential Equations: Phase plane, conservation systems, structure of trajectory near-an-equilibrium point, periodic solution, limit cycles, Vander Pol equation, competing population, Volterra model.


Recommended Book:

5. 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.
PEE-508  H.V.D.C. TRANSMISSION

L: 4  MARKS  Hrs.
Uni. Exam.  100  03
Sessional  50


3. Equivalent Circuit of HVDC link, Basic means of control of HVDC link, CIA, CEA&CC, control characteristics, combined characteristics of a converter.


7. Introduction to multi-terminal HVDC systems.

8. Protective system in HVDC substations.

**Recommended Books:**


**Note:**

1. Eight questions well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
**Fundamentals:** Types of relays, their classifications and theory Phase and amplitude comparators. Static Comparators Computer Applications to protective relaying.


**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, Overfluxing protection of transformers.

**Differential Relays:** Operating Characteristics, Restraining Characteristics, Analysis of Electromagnetic and differential Static relays schemes.

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

**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.

**Recommended Books:**
Note:
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.

PEE-510 Industrial Automation Lab

<table>
<thead>
<tr>
<th>Marks</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>Int.</td>
<td>50</td>
</tr>
<tr>
<td>Ext.</td>
<td>50</td>
</tr>
</tbody>
</table>

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:
Students will undertake hardware/software project work keeping in view the recent trends of Research/development related to power Engg/Electrical Engg.

Note: No theory exam. is to be conducted.
PEE-512  SEMINAR

Hrs./Week:  2  
Int. Marks :  100  
Ext. Marks:  Nil  

Students will undertake an extensive study of/from National/International journals, Internet etc. related to a latest topic in the area of Power Engg. and will deliver a seminar on the relevant topic.

Note:- No theory Exam. is to be conducted.
1. Introduction:
   Classification of electromechanical transients, Steady state, transient and resultant
   stabilities, basis for representation of power systems as two machines and multi-
   machine system.

2. Steady state and transient characteristics of a two machine systems:
   a) Phasor diagrams and expressions for active and reactive power in terms of
      voltages Eq., Eq', and Vg for salient and non salient pole machines (excluding
      resistance). Derivation of power expressions including resistance.
   b) Characteristics of sending end generator at synchronous speed.
   c) Characteristics of the generator at asynchronous speed.

3. Steady State and transient characteristics of multi-machine system:
   a) Characteristics of linear system with machines running at asynchronous speed.
   b) Characteristics of linear system with machine running at synchronous speed.
   c) Characteristics of non-linear elements.

4. Steady state stability of two machine systems:
   a) Unregulated case: Simple analysis of steady state stability, effect of damping
      and turbine regulation on small oscillations, effect of induced currents in field
      winding.
   b) Regulated case: Characteristics and types of excitation systems, forced
      excitation system. transfer function of automatically regulated synchronous
      machine, stability analysis with forced excitation regulator, influence of
      automatically regulated machine on the small oscillations in the systems.

5. Steady state stability of multi-machine systems.

6. Transient stability of two machine systems
   Equal area criterion, swing equation, approximate solution of swing equation, effect
   of excitation and turbine control.

7. Transient Stability of multi-machine systems, transient stability of interconnected
   power systems, introduction to asynchronous operation of synchronous machines.

8. Stability improvement measures in power systems.

Recommended Books:
1. Transient phenomenon to power systems by Venikov V.A.
2. Introduction to Electrical Energy System by O. I Elgerd.
5. Power System Analysis by Stevenson.

Note:
1. Eight questions well distributed out of entire syllabus, are to be set.
2. Five question are to be attempted.
Introduction to EHV AC Transmission, Tower Configurations, types of self supporting Lattice towers, Flexible and Semi Flexible towers.

Thermal Rating of Lines, Temperature rise of conductors and current carrying capacity of lines and cables, properties of bundled conductor, Average value of line parameters, power handling capacity and line loss, selection of cable for EHV AC transmission, Electrical characteristics and cable insulating materials . Types of circuit breakers for EHV AC system.

**Voltage gradient of conductors:** field of line charges and their properties , surface voltage gradient on conductors, maximum surface voltage gradient . Corona Effects, Corona formulas based on voltages and voltage gradients, Corona currents, Power loss, Audible Noise and Radio interference , Limits of audible noise, AN measurements ,day night equivalent noise level.

**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.

**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.

Design of EHV Lines based on Steady-State limits, transients, voltage stability, series and shunt compensation, reactive power control apparatus.

**Recommended Books:**

2. Transmission Line Reference Book: 345 KV and above EPRI, Palo Alto USA.
5. 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.
PEE-515  Reliability Engg.

L: 4  MARKS  Hrs.
Uni. Exam.  100  03
Sessional  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:

4. Probability distributions in reliability Evaluation:
   General reliability function, Poisson distribution, normal distribution, exponential distribution.

5. Discrete Markov Chains:

6. Continuous Markov Processes:
   General modeling concepts, state space diagrams, Stochastic transitional probability matrix, Evaluating limiting state probabilities.

Books:--

Note:
3. Eight questions, well distributed out of the entire syllabus, are to be set.
4. Five questions are to be attempted.
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.


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.

Microprocessor applications to Power Engg.

Protective Relaying: over-current, impedance, MHO, reactance, bi-directional relays.


Recommended Books:

Note:
1. Eight questions, well distributed out of the entire syllabus are to be set.
2. Five questions are to be attempted.
1. **Transducers**: Classification of Transducers including analog and digital transducers, Selection of Transducers, Static and Dynamic response of transducer System.


3. **Telemetry**: Basic Principles, Proximity & remote Action Telemetry systems, Multiplexing; Time Division and frequency division.


5. Fibre Optic Technology for data transmission, Supervisory Control and Data Acquisition Systems (SCADA), Q-meter.

6. Electrical noise in control signals, its remedial measures.

**Recommended Books:**

1. W.D. Cooper & A.D. Helfrick, Electronic Instrumentation and Measurement Techniques, PHI.
4. Electrical Transducers for Industrial Measurement by pH Mansfields.
5. Instrumentation systems by Mani Sharma, Rangan.
7. Telemetry Method by Foster.

**Note:**

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
Fast Transients in Power Systems

1. 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 reflections, Traveling waves on multi-conductor systems. Transition points on multi conductor circuits.

2. **Lightening**: Charge formation. Mechanism of lightening stroke, Mathematical model of lightening stroke.

3. **Theory or Ground Wires**: Direct Stroke to a tower, Effect of reflection up and down the tower, the counterpoise.

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

5. Protection of transmission systems against surge.

6. High frequency oscillations and terminal transients of transformer.

7. Insulation co-ordination.

**References Books:**


**Note:**

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. **Introduction**: Need for energy efficient machines, energy cost and two part tariff, energy conservation in industries and farms - a necessity, introduction to energy management and energy audit system.

2. Review of induction motor characteristics.


4. **The Power factor**: The p.f in sinusoidal systems, p.f improvement, the p.f with non-linear loads, Harmonics and the p.f.

5. **Application of Electric motors**: Varying duty applications, Voltage variation, Voltage Unbalance, Over motoring, Poly-phase induction motors supplied by adjustable frequency power supplies.

6. **Induction motors and adjustable drive Systems**: Energy Conservation, adjustable sPEd systems, Application of adjustable sPEd systems to fans, pumps and constant torque loads.

7. **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.

**Recommended Books:**


**Note:**

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. **Introduction:** Concept and classifications, Selection.

2. **Dynamics of Electrical Drives:** Loads, Quadrantal diagram of sPEd-torque Characteristics, Load torque variation, Dynamics of motor load combination, Steady state and transient Stability of electric drive.

3. **Review of motor Characteristics:** Modified sPEd-torque characteristics of d.c. shunt and series motors, Modified sPEd-torque characteristics of three phase induction motor, Variation of applied voltage, Variation of Supply frequency.


6. **D.C. Motor Drives:** Controlled rectifier d.c. drives, Chopper-fed d.c. motor drives, Separately excited and series motors, Steady State Performance.

7. **Induction Motor Drives:** Variable frequency control, slip power control, Chopper controlled resistance in the rotor Circuit.

8. **Industrial Applications:** Steel mills, Hot and Cold rolling mills, Paper Mills, Cement Mills.

**Recommended Books:**
3. Thyristor d.c. drives by S.K. Sen.
4. Electric Machines and Drives by Fransua.
6. Related IFEE/IEE Publications.

**Note:**

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. **Introduction to Energy Sources:** World Energy Futures, Conventional Energy Sources, Non Conventional Energy Sources, Prospects of Renewable Energy Sources.

2. **Solar Energy:**

3. **Wind Energy:**
   a) Introduction to wind energy Conversion, the nature of the wind, Power in the wind.

4. **Direct Energy Conversion Processes:**
   b) Thermo-Electric Generation: Basic principles of thermo-electric power-generation, Seebeck, Peltier, Thomson effects, Thermo-Electric power generator, Analysis, materials.
   c) Thermionic Generation: Thermionic emission and work function, Basic thermionic generation.
   d) Fuel Cells $H_2O_2$ Cell, Classification of fuel Cells, Types, Advantages, Electrodes, Polarization.
   e) Thermo Nuclear Fusion Energy: The basic Nuclear Function and Reactions Plasma Confinement, Thermo Nuclear function Reactions.

5. **Energy From Biomass:**
Reference Books:
2. Bio Energy by David Boyles, Elis Horwood Ltd.,

Note:

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. **Basic Reliability Concepts:**
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:**


**Note:**
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. **Introduction**: Review of load forecasting, the electric utility industry, growth characteristics generation, transmission and distribution systems.

2. **Generation System Planning**: Optimal scheduling of generation units, Optimal power flow, Optimal scheduling of hydro-thermal power system, Unit commitment, Reliability based generation system, Expansion planning, Unit maintenance schedule, Unit effective load carrying capability, Generation system cost analysis.

3. **Transmission System Planning**: Automatic transmission system expansion planning, Automatic transmission planning using interactive graphics.

4. **Distribution System Planning and Automation**: 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.

**Recommended Books:**

**Note:**
1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
1. Introduction: Communication links required in telemetry, tele-control and tele protection.

2. Analog and digital communication: SPEd and banding requirements, Noise in power systems.


4. Requirements of various communication equipments used in power systems.

5. Computer networking in power systems.

Recommended Books:

7. Computer Network by Tanenbaum

Note:

1. Eight questions, well distributed out of the entire syllabus, are to be set.
2. Five questions are to be attempted.
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:**
   Standard form of linear programming, Graphical solution, Simplex method, Two-phase simplex method, Computer implementation of the simplex method, Duality theory.

4. **Transportation Problem:**
   North-West Corner rule, Least cost method, Vogel approximation method, testing for optimality.

5. **Non-Linear Programming: One–dimensional minimization methods:**
   Unimodal function, Dichotomous search, Fibonacci search, Quadratic interpolation method, Cubic interpolation method.

6. **Non-Linear Programming-Unconstrained Optimization Techniques:**
   Random search method, Steepest descent method, Conjugate gradient method, Variable metric method.

7. **Non-Linear Programming - Constrained Optimization Techniques:**
   Interior Penalty function method, Exterior penalty function method.

8. **Further Topics in Optimization:**
   Critical path method (CPM), Program evaluation and review technique (PERT).

**Books:-**

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

2. Basic Hop field model, Basic learning laws, Unsupervised learning, Competitive learning, K-means clustering algorithm, Kohonen’s feature maps.


4. Application of neural nets such as pattern recognition, Optimization, Associative memories, sPEch and decision-making. VLSI implementation of neural networks.


**Books Recommended:**
1. Neural Networks by Simon Haykin
2. Fuzzy logic with engineering application by ROSS J.T (Tata Mc)
3. Neural Networks & Fuzzy Logic by Bart Kosko
5. Introduction to applied Fuzzy Electronics by Ahmed M. Ibrahim (PHI)
6. Introduction to artificial neural systems by J.M. Zurada (Jaico Pub)
7. An Introduction to Fuzzy control by D. Driankor, H. Hellendorn, M. Reinfrank (Narosa Pub)
8. Fuzzy Neural Control by Junhong NIE & DEREK LINKERS (PHI)

**Note:** Eight questions of equal marks to be set covering the whole syllabus and any five to be attempted.