DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEEIRNG
FACULTY OF ENGINEEIRNG
PG PROGRAM (CBCS) – M.E POWER SYSTEMS ENGINEERING (PART TIME)
(2020–2021 Batch and onwards)

Course Code	Name of the Course	Category	Objective		Instruction			Credit(s)	Maximum Marks			Page No.
			PEOs	POs	L	T	P		CIA	ESE	Total	
SEMESTER – I												
20PMEPS101	Power System Analysis	PCC	1, 2, 3	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	4
20PMEPS102	Power System Dynamics-I	PCC	1, 2, 4	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	5
20PMEPS103 A/B/C/D	Renewable Energy System/ Smart grids/ High Power Converters/ Wind and Solar Systems	PE	1, 2, 4	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	6/7/9/10
Total					**9**	**0**	**0**	**9**	**120**	**180**	**300**	9
SEMESTER – II												
20PMEPS201	Digital Protection of Power System	PCC	1, 2, 3	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	11
20PMEPS202	Power System Dynamics-II	PCC	1, 2, 4	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	12
20PMEPS203 A/B/C/D	Electrical Power Distribution System/ Mathematical Methods for Power Engineering/ Pulse Width Modulation for PE Converters/ Electric and Hybrid Vehicles	PE	1, 2, 4	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	13/14/15/16
Total					**9**	**0**	**0**	**9**	**120**	**180**	**300**	**9**

SEMESTER- III												
20PMEPS301 A/B/C/D	Restructured Power Systems/Advanced Digital Signal Processing / Dynamics of Electrical Machines/ Power Apparatus Design	PE	1, 2, 3	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	17/18/ 19/20
20PMEPS302 A/B/C/D	Advanced Micro-Controller Based Systems/SCADA System and Applications/ Power Quality/ Artificial Intelligence Techniques	PE	1, 2, 3	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	22/23/ 25/27
20PMEPS303	Research Methodology and IPR	HSMC	1, 2, 4	a, b, d	**3**	**0**	**0**	**2**	**40**	**60**	**100**	28
20PMEPS311	Power System Steady State Analysis Lab	PCC			**0**	**0**	**3**	**2**	**40**	**60**	**100**	30
Total					**9**	**0**	**3**	**10**	**160**	**240**	**400**	
SEMESTER IV												
20PMEPS401 A/B/C	Power System Transients/ FACTS and Custom Power Devices/Industrial Load Modeling and Control	PCC	1, 2, 3	a, b, d, f	**3**	**0**	**0**	**3**	**40**	**60**	**100**	31/32/ 34
20PMEPS402 A/B/C/D/E/F	Business Analytics/ Industrial Safety/ Operations Research/ Cost Management of Engineering Projects/ Composite Materials/ Waste to Energy	OE	1, 2, 4	a, d, f, h	**3**	**0**	**0**	**3**	**40**	**60**	**100**	36/38/ 40/41/ 43/45
20PMEPS411 A/B	Power System Dynamics Lab/ Renewable Energy Lab	PCC			**0**	**0**	**3**	**2**	**40**	**60**	**100**	47
Total					**6**	**0**	**3**	**8**	**120**	**180**	**300**	
SEMESTER -V												
20PMEPS511 A/B	Power System Protection	**PCC**			**0**	**0**	**3**	**2**	**40**	**60**	**100**	48/49

	Lab/Power Quality Lab											
20PMEPS591	Project Phase I				**0**	**0**	**9**	**6**	**40**	**60**	**100**	
Total					**0**	**0**	**12**	**8**	**80**	**120**	**200**	
SEMESTER -VI												
20PMEPS691	Phase-II Dissertation	**PCC**			**0**	**0**	**18**	**12**	**120**	**180**	**300**	
Total					**0**	**0**	**18**	**12**	**120**	**180**	**300**	
Program Total					**33**	**0**	**36**	**56**	**720**	**1080**	**1800**	

L: Lecture Hour **T**: Tutorial Hour **CIA**: Continuous Internal Assessment

P: Practical Hour **C:No**. of Credits **ESE**: End Semester Examinations

PCC – Programme Core Course **PE** - Program Elective

OE – Open Elective **HSMC**-Humanities, Social Science and Management Course

20PMEPS101	**POWER SYSTEM ANALYSIS**	**Semester – I** **3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives-

1. Study various methods of load flow and their advantages and disadvantages
2. Understand how to analyze various types of faults in power system
3. Understand power system security concepts and study the methods to rank the contingencies
4. Understand need of state estimation and study simple algorithms for state estimation
5. Study voltage instability phenomenon

Course outcomes-

Students will be able to:

1. Able to calculate voltage phasors at all buses,
2. Able to calculate the data using various methods of load flow
3. Able to calculate fault currents in each phase
4. Rank various contingencies according to their severity
5. Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc
6. Estimate closeness to voltage collapse and calculate PV curves using continuation power flow

Unit I

Load flow: Overview of Newton-Raphson ,Gauss-Siedel - fast decoupled methods, onvergence properties, sparsity techniques, handling Q- max violations in constant matrix, inclusion in frequency effects - AVR in load flow, handling of discrete variable in load flow.

Unit II

Fault Analysis: Simultaneous faults, open conductors faults, generalized method of fault analysis.

Unit III

Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking

Unit IV

Power System Equivalents : WARD – REI equivalents - State Estimation : Sources of errors in measurement - Virtual and Pseudo, Measurement, Observability

Unit V

Tracking state estimation, WSL method, bad data correction - Voltage Stability : Voltage collapse, P-V curve, multiple power flow solution, continuation power flow, optimal multiplies load flow, voltage collapse proximity indices.

Suggested reading

1. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003
A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000
L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006
G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986
A.J. Wood, " Power generation, operation and control" , John Wiley, 1994
P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995

20PMEPS102	POWER SYSTEM DYNAMICS - I	Semester – I 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:
1. Study of system dynamics and its physical interpretation
2. Development of mathematical models for synchronous machine
3. Modeling of induction motor

Course Outcomes:
Students will be able to:
1. Understand the modeling of synchronous machine in details
2. Understand the formulation of state space equation
3. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI POWER
4. Carry out stability analysis with power system stabilizer (PSS)
5. Carry out stability analysis without power system stabilizer (PSS)
6. Understand the load modeling in power system

Unit I 8
Synchronous Machines: Per unit systems, Park's Transformation (modified), Flux-linkage equations.

Unit II **8**
Voltage and current equations, Formulation of State-space equations, Equivalent circuit.

Unit III 6
Sub-transient and transient inductance and Time constants, Simplified models of synchronous machines

Unit IV **10**
Small signal model: Introduction to frequency model, Excitation systems and Philips-Heffron model, PSS Load modeling.

Unit V **6**
Modeling of Induction Motors, Prime mover controllers.

Suggested reading:-
1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi, 1981
2. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997
3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

20PMEPS103A	RENEWABLE ENERGY SYSTEM	Semester – I 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:
1. To learn various renewable energy sources
2. To gain understanding of integrated operation of renewable energy sources
3. To understand Power Electronics Interface with the Grid

Course Outcomes:
Students will be able to:
1. Knowledge about renewable energy
2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System
4. Understand the concept of DG
5. Knowledge about Impact of Distributed Generation
6. Understand the concept of Transmission System Operation

Unit I **8**
Introduction, Distributed vs Central Station Generation, Sources of Energy such as Micro-turbines, Internal Combustion Engines.

Unit II **8**
Introduction to Solar Energy, Wind Energy, Combined Heat and Power, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass and Fuel Cells.

Unit III
Power Electronic Interface with the Grid

Unit IV **8**
Impact of Distributed Generation on the Power System, Power Quality Disturbances

Unit V 8
Transmission System Operation, Protection of Distributed Generators - Economics of Distributed Generation

Suggested reading
1. RanjanRakesh, Kothari D.P, Singal K.C, “Renewable Energy Sources and Emerging Technologies”,
2nd Ed. Prentice Hall of India ,2011
2. Math H.Bollen, Fainan Hassan, “Integration of Distributed Generation in the Power System”, July 2011,
Wiley –IEEE Press
3. Loi Lei Lai, Tze Fun Chan, “Distributed Generation: Induction and Permanent Magnet Generators”,
October 2007, Wiley-IEEE Press.
4. Roger A.Messenger, Jerry Ventre, “Photovoltaic System Engineering”, 3rd Ed, 2010
5. James F.Manwell, Jon G.McGowan, Anthony L Rogers, “Wind energy explained: Theory Design and Application”, John Wiley and Sons 2nd Ed, 2010

20PMEPS103B	**SMART GRIDS**	**Semester – I 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understanding the problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes

Students will be able to:

1. Appreciate the difference between smart grid & conventional grid
2. Apply smart metering concepts to industrial installations
3. Apply smart metering concepts to commercial installations
4. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
5. Come up with smart grid solutions using modern communication technologies
6. Understand the concept of Power Quality & EMC in Smart Grid

Unit I

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid Present development & International policies in Smart Grid 8

Unit II

Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation . 8

Unit III

Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS) Phase Measurement Unit(PMU) 8

Unit IV

Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines Captive power plants, Integration of renewable energy sources 8

Unit V

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit, Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area, Network (NAN), Wide Area Network (WAN)

Suggested reading

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012
4. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions " CRC Press
5. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer

20PMEPS103C	**HIGH POWER CONVERTERS**	**Semester – I 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. Understand the requirements of high power rated converters
2. Understand the different topologies involved for these converters
3. Able to understand the design of protection circuits for these converters

Course Outcomes:-

Students will be able to:

1. Learn the characteristics of PSDs such as SCRs, GTOs, IGBTs and use them in practical systems
2. Knowledge of working of multi-level VSIs,
3. Knowledge of working of DC-DC switched mode converters,
4. Knowledge of working of cyclo-converters and PWM techniques and the ability to use them properly
5. Acquire knowledge of power conditioners and their applications
6. Ability to design power circuit and protection circuit of PSDs and converters

Unit I

Power electronic systems, An overview of PSDs, multipulse diode rectifier, multipulse, SCR rectifier. 6

Unit II

Phase shifting transformers, multilevel voltage source inverters: two level voltage source inverter, cascaded, H bridge multilevel inverter. 8

Unit III

Diode clamped multilevel inverters, flying capacitor multilevel inverter 6

Unit IV

PWM current source inverters,DC to DC switch mode converters, AC voltage controllers : Cyclo-converters, matrix converter, Power conditioners and UPS. 8

Unit V

Design aspects of converters, protection of devices and circuits 6

Suggested reading

1. N. Mohan, T. M. Undeland and W. P. Robbins, “Power Electronics: Converter, Applications and Design”,John Wiley and Sons, 1989
2. M.H. Rashid, “Power Electronics”, Prentice Hall of India, 1994
3. B. K .Bose, “Power Electronics and A.C. Drives”, Prentice Hall, 1986
4. Bin Wu, “High power converters and drives”, IEEE press, Wiley Enter science

20PMEPS103D	**WIND AND SOLAR SYSTEMS**	**Semester – I**
		3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. To get exposure to wind and solar systems
2. To understand the factors involved in installation and commissioning of a Solar or Wind plant.
3. Learning the dynamics involved when interconnected with power system grid

Course Outcomes:-

Students will be able to:

1. Appreciate the importance of energy growth of the power generation from the renewable energy sources and participate in solving these problems
2. Demonstrate the knowledge of the physics of wind power and solar power generation and all associated issues so as to solve practical problems
3. Demonstrate the knowledge of physics of solar power generation and the associated issues
4. Identify, formulate and solve the problems of energy crises using wind and solar energy
5. Understand the concept of Isolated wind systems
6. Understand the concept of Energy Storage device

Unit I

Historical development and current status, characteristics of wind power generation, network integration issues 8

Unit II

Generators and power electronics for wind turbines, power quality standards for wind turbines, Technical regulations for interconnections of wind farm with power systems. 8

Unit III

Isolated wind systems, reactive power and voltage control, economic aspects. 8

Unit IV

Impacts on power system dynamics, power system interconnection 8

Unit V

Introduction of solar systems, merits and demerits, concentrators, various applications. Solar thermal power generation, PV power generation, Energy Storage device. Designing the solarsystem for small installations. 6

Suggested reading

1. Thomas Ackermann, Editor, “Wind power in Power Systems”, John Willy and sons ltd.2005
2. Siegfried Heier, “Grid integration of wind energy conversion systems”, John Willy and sons ltd., 2006
3. K. Sukhatme and S.P. Sukhatme, “Solar Energy”. Tata MacGraw Hill, Second Edition, 1996

20PMEPS201 DIGITAL PROTECTION OF POWER SYSTEM **Semester – II 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. Study of numerical relays
2. Developing mathematical approach towards protection
3. Study of algorithms for numerical protection

Course Outcomes

1. Learn the importance of Digital Relays
2. Apply Mathematical approach towards protection
3. Learn to develop various Protection algorithms
4. Learn to develop various Digital filtering.
5. Learn Walsh function based algorithm

Unit I

Evolution of digital relays from electromechanical relays-Performance and operational characteristics of digital protection

Unit II

Mathematical background to protection algorithms - Finite difference techniques

Unit III

Interpolation formulae-• Forward, backward and central difference interpolation-Numerical differentiation - Curve fitting and smoothing-Least squares method -Fourier analysis - Fourier series and Fourier transform - Walsh function analysis - Basic elements of digital protection - Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers

Unit IV

Conversion subsystem: the sampling theorem, signal aliasing- Error, sampleand hold circuits, multiplexers, analog to digital conversion - Digital filtering concepts, The digital relay as a unit consisting of hardware and software - Sinusoidal wave based algorithms - Sample and first derivative (Mann and Morrison) algorithm.

Unit V

Fourier and Walsh based algorithms - Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm. - Walsh function based algorithm. Least Squares based algorithms. Differential equation based algorithms. Traveling Wave based Techniques. Digital Differential Protection of Transformers. Digital Line Differential Protection. Recent Advances in Digital Protection of Power Systems. 8

Suggested reading

1.A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009
2.A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999
3.Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006 4.S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014

20PMEPS202	POWER SYSTEM DYNAMICS-II	Semester – II 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:-
Students will be able to:
1. Study of power system dynamics
2. Interpretation of power system dynamic phenomena
3. Study of various forms of stability

Course Outcomes:-
Students will be able to:
1. Gain valuable insights into the phenomena of power system including obscure ones.
2. Understand the power system stability problem.
3. Analyze the stability problems and implement modern control strategies.
4. Simulate small signal stability problems.
5. Simulate large signal stability problems.

Unit - I
Basic Concepts of Dynamic Systems and Stability Definition - Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System

Unit - II
Effect of Damper, Flux Linkage Variation and AVR - Large Signal Rotor Angle Stability - Dynamic Equivalents And Coherency-Direct Method of Stability Assessment Stability Enhancing Techniques - Mitigation Using Power System Stabilizer 8

Unit III
Asynchronous Operation and Resynchronization - Multi-Machine Stability - Dynamic Analysis of Voltage Stability

Unit IV
Voltage Collapse - Frequency Stability - Automatic Generation Control

Unit V
Primary and Secondary Control - Sub-Synchronous Resonance and Counter Measures

Suggested reading
1. P. Kundur, “Power System Stability and Control”, McGraw Hill Inc, 1994
2. J. Machowski, Bialek, Bumby, “Power System Dynamics and Stability”, John Wiley & Sons, 1997
3. L. Leonard Grigsby (Ed.); “Power System Stability and Control”, Second edition, CRC Press, 2007
4. V. Ajjarapu, “Computational Techniques for voltage stability assessment & control”; Springer, 2006

20PMEPS203A ELECTRICAL POWER DISTRIBUTION SYSTEM Semester – II
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:-Students will be able to:
1. Learning about power distribution system
2. Learning of SCADA System
3. Understanding Distribution Automation

Course Outcomes :-Students will be able to:
1. Knowledge of power distribution system
2. Study of Distribution automation and its application in practice
3. To learn SCADA system

Unit I

Distribution of Power, Management, Power Loads,Load Forecasting Short-term & Long-term, Power System Loading, Technological Forecasting.

Unit II

Advantages of Distribution Management System(D.M.S.) Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints Power Factor Correction 8

Unit III

Interconnection of Distribution, Control & Communication Systems, Remote Metering, • Automatic Meter Reading and its implementation SCADA: Introduction, Block Diagram, SCADA Applied To Distribution Automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA

Unit IV

Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial, Distribution Systems, Sectionalizing Switches – Types, Benefits, • Bellman's Optimality Principle, • Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring

Unit V

Maintenance of Automated Distribution Systems Difficulties in Implementing Distribution. Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation

Suggested reading

1. A.S. Pabla, " Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi
3. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press
4. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press

20PMEPS203B MATHEMATICAL METHODS FOR POWER ENGINEERING	Semester – II 3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. To understand the relevance of mathematical methods to solve engineering problems.
2. To understand how to apply these methods for a given engineering problem.

Course Outcomes:

Students will be able to:

1. Knowledge about vector spaces, linear transformation, eigenvalues and eigenvectors of linear operators
2. To learn about linear programming problems and understanding the simplex method for solving linear programming problems in various fields of science and technology
3. Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems
4. Understanding the concept of random variables, functions of random variable and their probability distribution
5. Understand stochastic processes
6. Understand the chastic classification

Unit I
Vector spaces - Linear transformations - Matrix representation of linear - transformation

Unit 2
Eigen values and Eigen vectors of linear operator - Linear Programming Problems - Simplex Method – Duality -Non Linear Programming problems

Unit 3
Unconstrained Problems - Search methods - Constrained Problems - Lagrange method - Kuhn-Tucker conditions - Random Variables - Distributions

Unit 4
Independent Random Variables

Unit 5
Marginal and Conditional distributions - Elements of stochastic processes

Suggested reading

1. Kenneth Hoffman and Ray Kunze, “Linear Algebra”, 2nd Edition, PHI, 1992
2. Erwin Kreyszig, “Introductory Functional Analysis with Applications”, John Wiley & Sons, 2004
3. Irwin Miller and Marylees Miller, John E. Freund’s “Mathematical Statistics”, 6th Edn, PHI, 2002
4. J. Medhi, “Stochastic Processes”, New Age International, New Delhi., 1994
5. A Papoulis, “Probability, Random Variables and Stochastic Processes”, 3rd Edition, McGraw Hill, 2002
6. John B Thomas, “An Introduction to Applied Probability and Random Processes”, John Wiley, 2000

20PMEPS203C PULSE WIDTH MODULATION FOR PE CONVERTERS **Semester-II 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:
1. To understand Necessity and Importance of PWM techniques
2. Implementation of PWM controllers

Course Outcomes:
Students will be able to:
1. Appreciate importance of PWM techniques
2. Implement PWM using different strategies
3. Control CSI using PWM
4. Control VSI using PWM
5. Pulse width modulation for multilevel inverters
6. Compare performance of converter for different PWM techniques

Unit I 8
Introduction to PE converters, Modulation of one inverter phase leg, Modulation of single phase - VSI and 3 phase VSI

Unit II 8
Zero space vector placement modulation strategies, Losses-Discontinuous modulation, Modulation of CSI

Unit III 8
Over modulation of converters, programme modulation strategies

Unit IV 8
Pulse width modulation for multilevel inverters - Implementation of modulation controller

Unit V 8
Continuing developments in modulation as random PWM, PWM for voltage unbalance, Effect of minimum pulse width and dead time

Suggested reading
1. D. Grahame Holmes, Thomas A. Lipo, “Pulse width modulation of Power Converter: Principles and Practice”, John Wiley & Sons, 03-Oct-2003
2. Bin Vew, “High Power Converter”, Wiley Publication
3. Marian K. Kazimicrczuk, “Pulse width modulated dc-dc power converter”, Wiley Publication

20PMEPS203D ELECTRIC AND HYBRID VECHILES Semester-II
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:
1. To understand upcoming technology of hybrid system
2. To understand different aspects of drives application
3. Learning the electric Traction

Course Outcomes: -
Students will be able to:
1. Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. To learn electric drive in vehicles / traction.
3. Basic concept of hybrid traction
4. Configuration and control of DC Motor drives
5. drive system efficiency
6. Classification of different energy management strategies

Unit I 8
History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance

Unit II 8
Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

Unit II 8
Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, drive system efficiency

Unit IV 8
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, supporting subsystems,

Unit V 8
Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies 6

Suggested reading
1. Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, “Sliding mode control of switching Power Converters”

20PMEPS301A RESTRUCTURED POWER SYSTEMS Semester-III
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:
1. Understand what is meant by restructuring of the electricity market
2. Understand the need behind requirement for deregulation of the electricity market
3. Understand the money, power & information flow in a deregulated power system

Course Outcomes:
Students will be able to:
1. Describe various types of regulations in power systems.
2. Identify the need of regulation
3. Identify the need of deregulation.
4. Define and describe the Technical and Non-technical issues in Deregulated Power Industry.
5 Identify and give examples of existing electricity markets.
6. Classify different market mechanisms and summarize the role of various entities in the market.

Unit I
Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization 8

Unit II
OPF: Role in vertically integrated systems and in restructured markets, congestion management 8

Unit III
Optimal bidding, Risk assessment, Hedging, Transmission pricing, Tracing of power 8

Unit IV
Ancillary services, Standard market design, Distributed generation in restructured markets 8

Unit V
Developments in India, IT applications in restructured markets, Working of restructured power systems, PJM, Recent trends in Restructuring 8

Suggested reading
1. LorrinPhilipson, H. Lee Willis, “Understanding electric utilities and de-regulation”, Marcel Dekker Pub.,1998.
2. Steven Stoft, “Power system economics: designing markets for electricity”, John Wiley and Sons, 2002.
3. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, “Operation of restructured power systems”, Kluwer Academic Pub., 2001.
4. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility”, Marcel Dekker.

20PMEPS301B ADVANCED DIGITAL SIGNAL PROCESSING Semester-III 3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:
1. To understand the difference between discrete-time and continuous-time signals
2. To understand and apply Discrete Fourier Transforms (DFT)

Course Outcomes:-
Students will be able to:
1. Knowledge about the time domain and frequency domain representations as well analysis of discrete time signals and systems
2. Study the design techniques for IIR and FIR filters and their realization structures.
3. Acquire knowledge about the finite word length effects in implementation of digital filters.
4. Knowledge about the various linear signal models and estimation of power spectrum of stationary random signals
5. Design of optimum FIR filters
6. Design of optimum IIR filters

Unit I
Discrete time signals, Linear shift invariant systems-Stability and causality, Sampling of continuous time signals- Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform - Z transform-Properties of different transforms 8

Unit II
Linear convolution using DFT, Computation of DFT Design of IIR digital filters from analog filters, Impulse invariance method, Bilinear transformation method 8

Unit III **8**
FIR filter design using window functions, Comparison of IIR and FIR digital filters, Basic IIR and FIR filter realization structures, Signal flow graph representations Quantization process and errors, Coefficient quantisation effects in IIR and FIR filters

Unit IV
A/D conversion noise- Arithmetic round-off errors, Dynamic range scaling, Overflow oscillations and zeroInput limit cycles in IIR filters, Linear Signal Models 8

Unit V
All pole, All zero and Pole-zero models, Power spectrum estimation- Spectral analysis of deterministic signals Estimation of power spectrum of stationary random signals , Optimum linear filters, Optimum signal estimation, Mean square error estimation 6

Suggested reading
1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",TataMc Grow-Hill Edition1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Grow Hill international editions. -2000

20PMEPS301C DYNAMICS OF ELECTRICAL MACHINES Semester-III 3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:

1. Learn Performance characteristics of machine
2. To understand the dynamics of the machine
3. To understand how to determine stability of machine
4. Learn the synchronous machine

Course Outcomes: -

Students will be able to:

1:Formulation of electrodynamic equations of all electric machines and analyze the performance characteristics

2: Knowledge of transformations for the dynamic analysis of machines

3: Knowledge of determination of stability of the machines under small signal and transient conditions

4: Study about synchronous machine

5. Large Signal Transient

6. Small Oscillation Equations

Unit I

Stability,Primitive 4 Winding Commutator Machine, Commutator Primitive Machine

- Complete Voltage Equation of Primitive 4 Winding Commutator Machine 8

Unit II

Torque Equation Analysis of Simple DC Machines using the Primitive Machine Equations, The Three Phase Induction Motor, Transformed Equations, Different Reference Frames for Induction Motor Analysis Transfer Function Formulation 8

Unit III

Three Phase Salient Pole Synchronous Machine, Parks Transformation, Steady State Analysis 8

Unit IV

Large Signal Transient, Small Oscillation Equations in State Variable form, Dynamical Analysis of Interconnected Machines 8

Unit V

Large Signal Transient Analysis using Transformed Equations, DC Generator /DC Motor System, Alternator /Synchronous Motor System 8

Suggested reading

1. D.P. Sengupta& J.B. Lynn,” Electrical Machine Dynamics”, The Macmillan Press Ltd. 1980
2. R Krishnan “Electric Motor Drives, Modeling, Analysis, and Control”, Pearson Education., 2001
3. P.C. Kraus, “Analysis of Electrical Machines”, McGraw Hill Book Company,1987
4. I. Boldia& S.A. Nasar,,”Electrical Machine Dynamics”, The Macmillan Press Ltd. 1992
5. C.V. Jones, “The Unified Theory of Electrical Machines”, Butterworth, London. 1967

20PMEPS301D POWER APPARATUS DESIGN **Semester-III 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. Study the modelling analysis of rotating machine.
2. Learning electromagnetic energy conversion
3. To know about rating of machines.

Course Outcomes: -

Students will be able to:

1. To give a systematic approach for modeling and analysis of all rotating machines under both transient and steady state conditions with the dimensions and material used
2. Ability to model and design all types of rotation machines including special machines
3. Principles of Design of Machines
4. Specific loadings
5. choice of flux density and current density
6. Choice of specific electric and magnetic loadings

Unit I

Principles of Design of Machines -Specific loadings, choice of magnetic and electric loadings, Real and apparent flux densities, temperature rise calculation, Separation of main dimension for DC machines, Induction machines and synchronous machines, Design of Transformers-General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling 8

Unit II

Specific loadings, choice of magnetic and electric loadings Real and apparent flux -densities, temperature rise calculation, Separation of main dimension for DC machines Induction machines and synchronous machines, Heating and cooling of machines, types of ventilation, continuous and intermittent rating 8

Unit III

General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes, Calculation of losses, efficiency and regulation, Forces winding during short circuit 8

Unit IV

General considerations, output equation, Choice of specific electric and magnetic loadings, efficiency, power factor, Number of slots in stator and rotor, Elimination of harmonic torques 8

Unit V

Design of stator and rotor winding, slot leakage flux, Leakage reactance, equivalent resistance of Magnetizing current, efficiency from design data , squirrel cage rotor, Types of alternators, comparison, specific loadings, output co-efficient, design of main dimensions - Introduction to Computer Aided Electrical Machine Design Energy efficient machines 10

Suggested reading

1. Clayton A.E, "The Performance and Design of D.C. Machines", Sir I. Pitman & sons, Ltd.
2. M.G. Say, "The Performance and Design of A.C. Machines ", Pitman
3. Sawhney A.K, "A course in Electrical Machine Design", DhanpatRai & Sons, 5th Edition

20PMEPS302A ADVANCED MICRO-CONTROLLER BASED SYSTEMS **Semester-III 3H-3C**

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. To understand the architecture of advance microcontrollers
2. To understand the applications of these controllers
3. To get some introduction to FPGA

Course Outcomes: -

Students will be able to:

1. To learn how to program a processor in assembly language and develop an advanced processor based system
2. To learn configuring and using different peripherals in a digital system
3. To compile and debug a Program
4. To generate an executable file and use it
5. Intel 8051
6. PIC 16F877

Unit I

Basic Computer Organization - Accumulator based Processes-Architecture - Memory Organization-I/O Organization 8

Unit II

Micro-Controllers-Intel 8051, Intel 8056- Registers, Memories, I/O Ports, Serial Communication, Timers, Interrupts, Programming 8

Unit III

Intel 8051 – Assembly language programming, Addressing-Operations, Stack & Subroutines Interrupts-DMA 8

Unit IV

PIC 16F877- Architecture Programming, Interfacing Memory/ I/O Devices, Serial I/O and data communication 8

Unit V

Digital Signal Processor (DSP), Architecture – Programming, Introduction to FPGA - Microcontroller development for motor control applications, Stepper motor control using micro controller

Suggested reading

1. John. F. Wakerly: "Microcomputer Architecture and Programming", John Wiley and Sons 1981
2. Ramesh S. Gaonker: "Microprocessor Architecture, Programming and Applications with the 8085",Penram International Publishing (India), 1994
3. Raj Kamal: "The Concepts and Features of Microcontrollers", Wheeler Publishing, 2005
4. Kenneth J. Ayala, "The 8051 microcontroller", Cengage Learning, 2004
5. John Morton," The PIC microcontroller: your personal introductory course", Elsevier, 2005

20PMEPS302B **SCADA SYSTEM AND APPLICATIONS** **Semester-III**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. To understand what is meant by SCADA and its functions
2. To know SCADA communication
3. To get an insight into its application

Course Outcomes:-

Students will be able to:

1Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications

2Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system

3 Knowledge about single unified standard architecture IEC 61850

4: To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server

5: Learn and understand about SCADA applications in transmission and distribution sector, industries etc

6. SCADA Communication

Unit I

Introduction to SCADA - Data acquisition systems - Evolution of SCADA - Communication technologies 8

Unit II

Monitoring and supervisory functions - SCADA applications in Utility Automation - Industries SCADA 6

Unit III

Industries SCADA System Components - Schemes- Remote Terminal Unit (RTU) - Intelligent Electronic Devices(IED) - Programmable Logic Controller (PLC) - Communication Network, SCADA Server, SCADA/HMI Systems 8

Unit IV

SCADA Architecture - Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850. 8

Unit V

SCADA Communication - various industrial communication technologies - wired and wireless methods and fiber optics - Open standard communication protocols - SCADA Applications: Utility applications - Transmission and Distribution sector operations, monitoring, analysis and improvement - Industries - oil, gas and water, Case studies, Implementation, Simulation Exercises 10

Suggested reading

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America
Publications,USA,2004
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related
Systems", Newnes Publications, Oxford, UK,2004
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003

20PMEPS302C **POWER QUALITY** **Semester-III**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

1. Understand the different power quality issues to be addressed
2. Understand the recommended practices by various standard bodies like IEEE,IEC, etc on voltage& frequency, harmonics
3. Understanding STATIC VAR Compensators

Course Outcomes: -

Students will be able to:

1: Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment and loads

2: To develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components

3: To introduce the student to active power factor correction based on static VAR compensators and its control techniques

4: To introduce the student to series and shunt active power filtering techniques for harmonics.

5. Static VAR compensators
6. Uninterruptible power supplies

Unit I 8

Introduction-power quality-voltage quality-overview of power quality phenomena, classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C, message weights-flicker factor transient phenomena-occurrence of power quality problems, power acceptability curves-IEEE guides, standards and recommended practices.

Unit II 8

Harmonics-individual and total harmonic distortion, RMS value of a harmonic waveform-Triplex harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

Unit III 8

Modeling of networks and components under non-sinusoidal, conditions transmission and distribution systems, Shunt capacitors-transformers-electric machines-ground, systems loads that cause power quality problems, power quality problems created by drives and its impact on drive

Unit IV 8

Power factor improvement- Passive Compensation, Passive Filtering, Harmonic, Resonance, Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC, Based on Bilateral Single Phase and Three Phase Converter

Unit V 10

Static VAR compensators-SVC and STATCOM Active Harmonic Filtering-Shunt Injection, Filter for single phase, three-phase three-wire and three-phase four- wire systems, d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage - transformers - series active power filtering techniques for harmonic cancellation and isolation, Dynamic Voltage Restorers for sag , swell and flicker problems. Grounding and wiring introduction - NEC grounding requirements-reasons for grounding - typical grounding and wiring problems solutions to grounding and wiring problems

Suggested reading

1. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007
2. Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000
3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,"Power system Harmonic Analysis", Wiley, 1997

20PMEPS302D ARTIFICIAL INTELLIGENCE TECHNIQUES Semester-III
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives:
1. Understanding fuzzy logic, ANN
2. Understanding GA & EP

Course Outcomes: -
Students will be able to:
1. Learn the concepts of biological foundations of artificial neural networks
2. Learn Feedback networks and radial basis function networks and fuzzy logics
3. Identifications of fuzzy and neural network
4. Acquire the knowledge of GA
5. Fuzzy Neural Networks
6. Genetic algorithm example

Unit I 8
Biological foundations to intelligent Systems, Artificial Neural Networks, Single layer and Multilayer Feed Forward NN, LMS and Back Propagation Algorithm, Feedback networks and Radial Basis Function Networks

Unit II 8
Fuzzy Logic, Knowledge Representation and Inference Mechanism, Defuzzification Methods

Unit III 10
Fuzzy Neural Networks, some algorithms to learn the parameters of the network like GA, System Identification using Fuzzy and Neural Network

Unit IV 8
Genetic algorithm, Reproduction cross over, mutation, Introduction to evolutionary program

Unit V 8
Applications of above mentioned techniques to practical problems

Suggested reading
1. J M Zurada , "An Introduction to ANN",Jaico Publishing House
2. Simon Haykins, "Neural Networks", Prentice Hall
3. Timothy Ross, "Fuzzy Logic with Engg.Applications", McGraw. Hill
4. Driankov, Dimitra, "An Introduction to Fuzzy Control", Narosa Publication
5. Golding, "Genetic Algorithms", Addison-Wesley Publishing Com

20PMEPS303 RESEARCH METHODOLOGY AND IPR **Semester-III**
3H-2C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives:

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics

Course Outcomes:

- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
- Effective technical writing
- Nature of Intellectual Property
- Patent Rights

Unit 1

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2

Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological

Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested reading

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

20PMEPS311 POWER SYSTEM STEADY STATE ANALYSIS LAB Semester-III
3H-2C

Instruction Hours/week: L:0 T:0 P:3 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

1. Experiments
2. Power Systems & Power Electronics Lab
3. Computer Simulation Lab
4. Simulation of IGBT Inverters.
5. Simulation of Thyristor Converters.
6. Transient Stability Studies.
7. Short Circuit Studies.
8. Load Flow Studies
9. Load Forecasting and Unit Commitment

20PMEPS401A POWER SYSTEM TRANSIENTS Semester - IV
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives

1. Learn the reasons for occurrence of transients in a power system
2. Understand the change in parameters like voltage & frequency during transients
3. To know about the lightning phenomenon and its effect on power system

Course Outcomes

Students will be able to

1. Knowledge of various transients that could occur in power system and their mathematical formulation
2. Ability to design various protective devices in power system for protecting equipment and personnel
3. Coordinating the insulation of various equipments in power system 4: Modelling the power system for transient analysis
4. Switching HVDC
5. Insulation co-ordination
6. Principle of digital computation

Units I 8 Hours

Fundamental circuit analysis of electrical transients, Laplace Transform method of solving simple Switching transients, Damping circuits - Abnormal switching transients, Three-phase circuits and transients - Computation of power system transients 8

Unit II 8 Hours

Principle of digital computation – Matrix method of solution - Modal analysis- Z transform- Computation using EMTP - Lightning, switching and temporary over voltages, Lightning - Physical phenomena of lightning.

Unit III 8 Hours

Interaction between lightning and power system - Influence of tower footing resistance and Earth Resistance - Switching: Short line or kilometric fault - Energizing transients - closing and re-closing of lines - line dropping, load rejection – over voltages induced by faults

Unit IV 8 Hours

Switching HVDC line Travelling waves on transmission line - Circuits with distributed Parameters Wave Equation - Reflection, Refraction, Behavior of Travelling waves at the line terminations - Lattice Diagrams – Attenuation and Distortion - Multi-conductor system - and Velocity wave

Unit V 8 Hours

Insulation co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS) Co- ordination between insulation and protection level Statistical approach - Protective devices - Protection of system against over voltages lightning arresters, substation earthling 6

Suggested reading: Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991

20PMEPS401B FACTS AND CUSTOM POWER DEVICES Semester - IV
3H-3C

Course Objectives

1. To learn the active and reactive power flow control in power system
2. To understand the need for static compensators
3. To develop the different control strategies used for compensation

Course Outcomes

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
2. Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled Reactive Power Systems, PWM_Inverter based Reactive Power Systems and their controls.
3. To develop analytical modeling skills needed for modeling and analysis of such Static VAR Systems.
4. Static series compensation
5. SSR and its damping Unified Power Flow Controller
6. interline power flow controller

Unit I 8 Hours

Reactive power flow control in Power Systems - Control of dynamic power unbalances in Power System - Power flow control - Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation - Uncompensated line -Shunt compensation, Series compensation Phase angle control - Reactive power compensation Shunt and Series compensation principles - Reactive compensation at transmission and distribution level

Unit II 8 Hours

Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM Operation and control of TSC, TCR and STATCOM -Compensator control Comparison between SVC and STATCOM

Unit III 8 Hours

Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators - TCVR and TCPAR Operation and Control - Applications, Static series compensation - GCSC, TSSC, TCSC and Static synchronous series compensators and their Control

Unit IV 8 Hours

SSR and its damping Unified Power Flow Controller - Circuit Arrangement, Operation - and control of UPFC - Basic Principle of P and Q control - Independent real and reactive power flow control- Applications

Unit V 8 Hours

Introduction to interline power flow controller - Modeling and analysis of FACTS – Controllers - Simulation of FACTS controllers Power quality problems in distribution systems, harmonics, loads that create harmonics, modeling, harmonic propagation, series and parallel resonances mitigation of harmonics, passive filters, active filtering – shunt , series and hybrid and their control - • Voltage swells , sags, flicker, unbalance and mitigation of these problems by power line conditioners - IEEE standards on power quality.

Suggested reading

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007
2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control", SpringerVerlag, Berlin, 2006
3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible
4. AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
5. K.S.Sureshkumar, S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut,2003
6. G T Heydt , "Power Quality", McGraw-Hill Professional, 2007
7. T J E Miller, "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982.

20PMEPS401C INDUSTRIAL LOAD MODELING AND CONTROL Semester – IV
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives

1. To understand the energy demand scenario
2. To understand the modeling of load and its ease to study load demand industrially
3. To know Electricity pricing models
4. Study Reactive power management in Industries

Course Outcomes

Students will be able to:

1. Knowledge about load control techniques in industries and its application
2. Learn different types of industrial processes and optimize the process using tools like LINDO and LINGO
3. Apply load management to reduce demand of electricity during peak time
4. Apply different energy saving opportunities in industries
5. Cooling and heating loads
6. Reactive power management in industries

Unit I **8 Hours**

Electric Energy Scenario-Demand Side Management-Industrial Load Management - Load Curves-Load Shaping Objectives - Methodologies-Barriers - Classification of Industrial – Loads - Continuous and Batch processes -Load Modeling

Unit II **8 Hours**

Electricity pricing – Dynamic and spot pricing –Models - Direct load control- Interruptible - load control - Bottom up approach- scheduling- Formulation of load – Models - Optimization and control algorithms - Case studies

Unit III **8 Hours**

Reactive power management in industries - controls-power quality impacts - application of filters Energy saving in industries

Unit IV **8 Hours**

Cooling and heating loads - Captive power units - Operating and control strategies - Power Pooling- Operation models - Energy banking - Industrial Cogeneration

Unit V **8 Hours**

Selection of Schemes Optimal Operating Strategies - Peak load saving - Constraints Problem formulation- Case study - Integrated Load management for Industries 6

Suggested reading

1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989
2. C.W. Gellings and S.N. Talukdar,. Load management concepts. IEEE Press, New York, 1986, pp. 3-28
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981
4. H. G. Stoll, "Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 1989.

5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995
6. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA

20PMEPS402A **BUSINESS ANALYTICS** **Semester – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course objective

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Course Outcomes

1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.
5. Mange business process using analytical and management tools.
6. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Unit I **9 Hours**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit II **8 Hours**

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit III **9 Hours**

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit IV **10 Hours**

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit V **12 Hours**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Reference:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

20PMEPS402B Industrial Safety **Semester – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives

1. Understand industrial safety problems
2. Learn Fundamentals of maintenance engineering
3. Introduction to Wear and Corrosion and their prevention
4. Fault tracing and Periodic and preventive maintenance

Course Outcomes

Students will be able to

1. Know the concept and steps of problem solving – industrial safety
2. Knowledge and understanding of maintenance engineering
3. Fundamentals of maintenance engineering
4. Wear and Corrosion and their prevention
5. Periodic and preventive maintenance
6. Wear and Corrosion and their prevention

Unit I

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit IV

Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, Electrical motors, Types of faults in machine tools and their general causes.

Unit V

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

20PMEPS402C Operations Research Semester – IV
3H-3C

Instruction Hours/week: L:3 T:0 P:0 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

Course Objectives

1. Understand the optimization techniques, models and LR formulation
2. Formulate LPP
3. Analyze Nonlinear programming problem

Course Outcomes

The student should be able to

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.
5. Scheduling and sequencing
6. Competitive Models

Unit I

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit II

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit III

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit IV

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit V

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

20PMEPS402D Cost Management of Engineering Projects **Semester – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives
1. Acquire and fine-tune the skills and techniques for the 4 phases in the life cycle of a typical project: initiating, planning, executing and closing
2. Gain an understanding of essential principles associated with effective project management and how to apply these principles in the day-to-day business environment
3. Familiarize yourself with commonly available computer software tools
4. Understand and apply methods for solving and avoiding common difficulties associated with project management.

Course Outcomes
1. Apply project selection methods to evaluate the feasibility of projects.
2. Assess project contribution to business strategy, purpose and plans.
3. Determine and document project goals and performance requirements by working closely with project stakeholders.
4. Define and document product or service deliverables.
5. Select appropriate project management practices, tools, and methodologies.
6. Define, analyze, refine, and document project requirements, assumptions, and constraints.

Unit I
Introduction and Overview of the Strategic Cost Management Process:Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit II
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non- technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance.

Unit III
Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

Unit IV
Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit V

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

20PMEPS402E Composite Materials **Semester – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course Objectives
1. Ability to solve mechanics of composite materials problems using classical methods
2. Ability to do research and present on an advanced material topic

Course Outcomes
1. Some understanding of types, manufacturing processes, and applications of composite materials
2. Ability to analyze problems on macro mechanical behavior of lamina
3. Ability to analyze problems on micro mechanical behavior of lamina
4. Ability to analyze problems on macro mechanical behavior of laminate
5. Ability to analyze problems on bending, buckling, and vibration of laminated plates and beams
6. Ability to obtain laminate behavior using a computer program
7. Ability to perform literature search on a selected advanced material topic and giving class presentation

UNIT I
INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II
REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT III
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT IV
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT V
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Text Books
1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.

2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

20PMEPS402F Waste to Energy **Semester – IV**
3H-3C

Instruction Hours/week: L:3 T:0 P:0 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

Course objectives

1. To enable students to understand of the concept of Waste Management, Minimization and Utilization.
2. To link legal, technical and management principles for effective waste management.
3. To learn about the best available technologies for waste processing.
4. To analysis of case studies for understanding success and failures.
5. To facilitate the students in developing skills in the decision making process

Course Outcomes

1. At the end of the course the student would have gained knowledge and understanding on various aspects of waste management, minimization and utilization.
2. Introduction to Energy from Waste
3. Biomass Gasification
4. Biomass Combustion
5. Properties of biogas
6. anaerobic digestion

Unit I

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit II

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit III

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit IV

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit V

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

20PMEPS411A POWER SYSTEM DYNAMICS LAB Semester – IV

3H-2C

Instruction Hours/week: L:0 T:0 P:3 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

S.No	Experiments
1	Power Curves
2	Build a Wind Farm
3	Test the Capabilities of the Hydrogen Fuel Cells and Capacitors

20PMEPS411B RENEWABLE ENERGY LAB Semester – IV
3H-2C

Instruction Hours/week: L:0 T:0 P:3 Marks: Internal:40 External:60 Total:100
End Semester Exam:3 Hours

S.No	Experiments
1	Effect of Temperature on Solar Panel Output
2	Variables Affecting Solar Panel Output
3	Effect of Load on Solar Panel Output
4	Wind Turbine Output: The Effect of Load
5	Test the Capabilities of Solar Panels and Wind Turbines

20PMEPS511A POWER SYSTEM PROTECTION LAB **Semester – V**
3H-2C

Instruction Hours/week: L:0 T:0 P:3 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

S.No	List of experiments:
1	Introduction to Power System Protection
2	Impact of Induction Motor Starting on Power System
3	Modelling of Differential Relay using MATLAB
4	Radial Feeder Protection

20PMEPS511B POWER QUALITY LAB **Semester – V**
3H-2C

Instruction Hours/week: L:0 T:0 P:3 **Marks: Internal:40 External:60 Total:100**
End Semester Exam:3 Hours

1 Parellel Feeder Protection

2 Principle of Reverse Power Protection

3 Differential Protection of Transformer

4 To the study time vs voltage characteristics of over voltage induction relay