Department: Electrical Engineering

Curriculum Structure for M. Tech. Under Autonomy (Effective from 2025-26 admission batch)

Specialization: Power Systems

1st Semester								
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. THEORY								
1	Core 1	PSM101	Application of Optimization Techniques in Power Systems	3	0	0	3	3
2	Core 2	PSM102	Advanced Power System Analysis	3	0	0	3	3
3	PE 1	PSM103	A. Power System Planning and Reliability B. Power System Dynamics C. Power Quality D. High Voltage Transmission System	3	0	0	3	3
4	PE 2	PSM104	A. Renewable Energy Systems and Microgrid B. Advanced Converter Technology C. Dynamics of Electrical Machines D. Electric Power Market Operations	3	0	0	3	3
B. PRACTICAL								
5	Lab 1	PSM191	Power System Optimization Laboratory	0	0	3	3	1.5
6	Lab 2	PSM192	Power System Steady State Analysis Lab	0	0	3	3	1.5
C. SESSIONAL								
8	Audit	PSM181	Term Paper on Energy Audit	0	0	0	0	3
Total of Theory, Practical and Sessional							**18**	**18**

2nd Semester								
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. THEORY								
1	Core 3	PSM201	Power System Operation and Control	3	0	0	3	3
2	Core 4	PSM202	Digital Protection of Power System	3	0	0	3	3
3	PE 3	PSM203	A. Power System Transient B. Smart Grid Technology C. Flexible A.C. Transmission System D. Restructured Electric Power Systems	3	0	0	3	3
4	PE 4	PSM204	A. Advanced Control System B. Modeling and Simulation of Dynamic Systems C. Advanced Microprocessor and Microcontroller D. Electric and Hybrid Vehicles	3	0	0	3	3
B. PRACTICAL								
5	Lab 3	PSM291	Advanced Power System Protection Laboratory	0	0	3	3	1.5
6	Lab 4	PSM292	Power Quality Laboratory	0	0	3	3	1.5
C. SESSIONAL								
7	Project 1*	PSM205	Research Methodology	0	0	0	0	2
8	Project 2	PSM281	Seminar	0	0	0	0	2
Total of Theory, Practical and Sessional							**18**	**19**

* Student should complete at least one MOOC course related to Research Methodology.

3rd Semester								
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. THEORY								
1	PE 5	PSM301	A. Dynamics of Linear Systems B. Energy Control Center – Concept and Implementation C. Advanced Digital Signal Processing D. AI Techniques	3	0	0	3	3
2	OE 1	PSM302	A. Business Analytics B. Industrial Safety C. Operations Research D. Cost Management of Engineering Projects	3	0	0	3	3
B. SESSIONAL								
3	Project 3	PSM 391	Dissertation (Phase – I)	0	0	20	20	10
Total of Theory, Practical and Sessional							**26**	**16**

4th Semester								
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. SESSIONAL								
1	Project 4	PSM491	Dissertation (Phase – II)	0	0	24	24	12
2	Project	PSM492	Comprehensive Viva-Voce	0	0	0	0	4
Total of Theory, Practical and Sessional							**24**	**16**

TOTAL CREDIT

Semester	**1st**	**2nd**	**3rd**	**4th**	**Total**
Credit	18	19	16	16	**69**

Detailed Syllabus

1st Semester								
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. THEORY								
1	Core 1	PSM101	Application of Optimization Techniques in Power Systems	3	0	0	3	3
2	Core 2	PSM102	Advanced Power System Analysis	3	0	0	3	3
3	PE 1	PSM103	A. Power System Planning and Reliability B. Power System Dynamics C. Power Quality D. High Voltage Transmission System	3	0	0	3	3
4	PE 2	PSM104	A. Renewable Energy Systems and Microgrid B. Advanced Converter Technology C. Dynamics of Electrical Machines D. Electric Power Market Operations	3	0	0	3	3
B. PRACTICAL								
5	Lab 1	PSM191	Power System Optimization Laboratory	0	0	3	3	1.5
6	Lab 2	PSM192	Power System Steady State Analysis Lab	0	0	3	3	1.5
C. SESSIONAL								
8	Audit	PSM181	Term Paper on Energy Audit	0	0	0	0	3
Total of Theory, Practical and Sessional							**18**	**18**

Paper Name: Application of Optimization Techniques in Power Systems
Paper Code: PSM101
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Formulate a design task as an optimization problem.
- **CO2.** Solve unconstrained optimization problems.
- **CO3.** Formulate constrained optimization problems and solve using corresponding methods.
- **CO4.** Solve discontinuous optimization problems using special methods.
- **CO5.** Solve nonlinear optimization problems with evolutionary methods.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	2	3
CO2	3	2	-	2	3
CO3	3	-	-	2	3
CO4	3	2	2	2	3
CO5	3	2	-	2	3

Course Content

Module 1: Introduction **8L**

Structure of a Generic Electric Power System, Power System Models, Power System Control, Power System Security Assessment, Power System Optimization as a Function of Time, Review of Optimization Techniques Applicable to Power Systems, Unconstrained Optimization Approaches, Linear Programming, Nonlinear Programming, Quadratic Programming, Newton's Method, Interior Point Methods, Mixed-Integer Programming, Intelligent Search Methods, Optimization Neural Network, Evolutionary Algorithms, Tabu Search, Particle Swarm Optimization, Application of Fuzzy Set Theory.

Module 2: Electric Power System Models **8L**

Introduction, Complex Power Concepts, Three-Phase Systems, Per Unit Representation, Synchronous Reactive Capability Limits, Prime Movers and Governing Systems, Automatic Gain Control, Transmission Subsystems, Y-Bus, Incorporating the Transformer Effect, Load Models, Available Transfer Capability (ATC), Loss Sensitivity Calculation, Calculation of Constrained Shift Sensitivity Factors, Definition of Constraint Shift Factors, Computation of Constraint Shift Factors, Generator Shift Factor Sensitivity.

Module 3: Power Flow Computations through Constrained Optimization **6L**

Introduction, Types of Buses for Power-Flow Studies, General Form of the Power-Flow Equations, Practical Modeling Considerations, Iterative Techniques for Power-Flow Solution, Theorems on the Optimization of Constrained functions, Procedure for the Optimizing Constrained Problems (Functions), Karush–Kuhn–Tucker Condition.

Module 4: Optimization Applications **7L**

Least Squares State Estimation, Weighted Least Squares Estimation, Bad Data Detection, Nonlinear Least Squares State Estimation, Linear Programming, Simplex Method, Interior Point Method, Nonlinear Programming, Quadratic Programming, Steepest Descent Algorithm, Sequential, Quadratic Programming Algorithm, Gaussian Elimination, LU Factorization, LU Factorization with Partial Pivoting, LU Factorization with Complete Pivoting, Optimal Power Flow, State Estimation.

Module 5: Applications in Power System by Optimization Techniques 7L

Priority Method, Dynamic Programming Method, Lagrange Relaxation Method, Newton Method.
Neglect Line Security Constraints, OPF Formulation. Security Corridors, Classic Method for Reactive Power Dispatch, Reactive Power Balance, Reactive Power Economic Dispatch, Linear Programming Method of VAR Optimization.

Text Books:

1. Electric Power System applications of Optimization by James A. Momoh.
2. Optimization of Power System Operation by Jizhong Zhu.

Reference Books:

1. Computational Methods for Electric Power System by Mariesa L, Crow.

Paper Name: Advanced Power System Analysis
Paper Code: PSM102
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics, Power System Analysis.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Remember proper mathematical models for analysis.
- **CO2.** Conclude methodologies of load flow studies for the power network.
- **CO3.** Apply contingency Analysis.
- **CO4.** Analyze power system studies.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	2	-	2	3
CO2	1	-	-	2	3
CO3	3	2	2	-	2
CO4	1	2	-	1	2

Course Content

Module 1: **8L**

Admittance Model and Network Calculations, Branch and Node Admittances, Mutually Coupled Branches in Y_{BUS}, An Equivalent Admittance Network, Modification of Y_{BUS}, Network Incidence Matrix and Y_{BUS}, Method of Successive Elimination, Node Elimination, Triangular Factorization, Sparsity and Near Optimal Ordering.

Module 2: **8L**

Impedance Model and Network Calculations, the BUS Admittance and Impedance Matrices, the venin's Theorem and Z_{BUS}, Algorithms for building Z_{BUS} Modification of existing ZBUS, Calculation of Z_{BUS} elements from YBUS, Power Invariant Transformations, Mutually Coupled Branches in $Z_{BUS.}$

Module 3: **5L**

Gauss Seidel method, N-R Method, Decoupled method, fast decoupled method, comparison between power flow solutions. DC load flow.

Module 4: **7L**

Z_{BUS} Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

Module 5: **8L**

Fault Analysis: Symmetrical faults, Fault calculations using Z_{BUS}- Fault calculations using Z_{BUS} equivalent circuits –Selection of circuit breakers- Unsymmetrical faults, Problems on various types of faults.

Text Books:

1. "Power System Analysis"- John J. Grainger and W. D. Stevenson, T.M.H. Edition.

2. Modern Power System Analysis– by I. J. Nagrath & D. P. Kothari Tata McGraw – Hill Publishing Company Ltd, 2nd edition.

Reference Books:

1. Power System Analysis and Design by J. Duncan Glover and M.S. Sarma., Cengage 3rd Edition.
2. "Electrical Energy Systems Theory"-Olle. L.Elgard, T.M.H. Edition.
3. Power systems stability and control, Prabha Kundur, The McGraw – Hill companies.
4. Power System Operation and Control, Dr. K. Uma Rao, Wiley India Pvt. Ltd.
5. Operation and Control in Power Systems, PSR Murthy, Bs Publications.
6. Power System Operation, Robert H. Miller, Jamesh H. Malinowski, The McGraw – Hill companies.
7. Power Systems Analysis, operation and control by Abhijit Chakrabarti, Sunitha Halder, PHI 3/e, 2010.

Paper Name: Power System Planning and Reliability
Paper Code: PSM103A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power System Analysis, Electric Power Generation, Transmission and Distribution.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Analyze a Generation System Model for the Power system in terms of frequency and duration of failure.
- **CO2.** Evaluate reliability indices of the power system based on system model and the load curve.
- **CO3.** Organize a small Generation and Transmission system, predict its behavior, and do the required change in order to achieve reliability.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	-	3	3
CO2	3	-	-	3	3
CO3	2	2	3	3	3

Course Content

Module 1: Load Forecasting — 9L

Load Forecasting Categories: Long term, medium term, short term, very short-term Applications of Load Forecasting, Factors Affecting Load Patterns Medium- and long-term load forecasting methods- end use models, econometric models, statistical model-based learning.

Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic-based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, STLF Using MATLAB'S ANN Toolbox, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis.

Module 2: Power System Reliability — 8L

Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

Module 3: Basic Tools and Techniques — 7L

Random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

Module 4: Reliability of Generation Systems — 6L

Capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion.

Module 5: Reliability Assessment for Elements of Transmission and Transformation Systems 6L

Reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines.

Text Books:

1. Power System Planning – R.L. Sullivan, Tata McGraw Hill Publishing Company.
2. Electrical Power System Planning – A.S Pabla, Macmillan India Ltd.
3. Reliability Evaluation of Power System – Roy Billinton and Ronald N Allan, Springer Publishers.

Reference Books:

1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, Shahidehpour M, Yamin H, Li z, John Wlley & sons.
2. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag.

Paper Name: Power System Dynamics
Paper Code: PSM103B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics, Power System Analysis.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** To explain the dynamic model.
- **CO2.** To select the appropriate model on which analysis to be done.
- **CO3.** To analyze the performance of the system with small signal analysis.
- **CO4.** To explain the controllers and their significance in power system.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	3	-	-	2
CO2	2	1	2	-	3
CO3	2	-	-	3	3
CO4	1	-	-	2	3

Course Content

Module 1: **10L**

Frequency Deviations in Practice, Small Disturbances and Deviations, Large Disturbances and Deviations, Typical Standards and Policies for "Active Power and Frequency, Control" or "Load Frequency Control", UCTE Load Frequency Control, Primary Control is by Governors, Secondary Control by Automatic Generation, Controls (AGCs), Tertiary Control, Self-Regulation of the Load, NERC (U.S.) Standards, Other Countries' Standards, System Modeling, Inertia, Droop, Regulation, and Dynamic Frequency Response, Block Diagram of the System Dynamics and Load Damping, Effect of Governor Droop on Regulation, Increasing Load by Adjusting Prime Mover Power, Parallel Operation of Several Generators, Isolated Area Modeling and Response, Governor Modeling, Response of a Simple Governor Model with Droop, Interconnected System Governor Simulations, AGC Principles and Modeling, AGC in a Single-Area (Isolated) System, AGC in a Two-Area System, Tie-Line Control, Frequency Bias, AGC in Multiarea Systems, Other Topics of Interest Related to Load Frequency Control, Spinning Reserves.

Module 2: **10L**

Relationship Between Active and Reactive, Powers and Voltage, Short Lines, Taking into Account the Shunt Admittance, Sensitivity Coefficients, Equipment for Voltage and Reactive Power Control, Reactive Power Compensation Devices, Shunt Capacitors, Shunt Reactors, Voltage and Reactive Power Continuous Control Devices, Synchronous Generators, Synchronous Compensators, Static VAr Controllers and FACTS Grid Voltage and Reactive Power Control Methods, General Considerations, Voltage–Reactive Power Manual Control Manual Voltage Control by Reactive Power Flow Manual Voltage Control by Network Topology Modification Voltage–Reactive Power Automatic Control.

Module 3: **9L**

Introduction, Classification of Power Systems Stability, Rotor Angle Stability, Small-Disturbance (or Small-Signal), Rotor Angle Stability, Large-Disturbance Rotor Angle Stability or Transient Stability, Voltage Stability Frequency Stability, Parallelism Between Voltage Stability and Angular

Stability, Importance of Security for Power System Stability, Power System States, Power Flow Security Limits, Services to Meet Power System Security Constraints, Dynamic Security Assessment, The Dynamic Matrix, Linearized Equations, Building the Dynamic Matrix, A General Simplified Approach, Inertia and Synchronizing Power Coefficients, Electromechanical Oscillations, Oscillation Modes, Oscillation Amplitudes and Participation Factors.

Module 4: **7L**

Direct Methods Based on Lyapunov's Theory, Lyapunov's Method, Designing the Lyapunov Function, Determination of Equilibrium, Extension of the Direct Lyapunov's Method, New Approaches Integration Methods for Transient Stability Assessment.

Text Books:

1. Power System Dynamics Stability and Control by K R Padiyar, B S Publications.
2. Power System Stability & Control, By- P. Kundur, Tata McGraw hill.

Reference Books:

1. Power Systems Analysis by Vijay Vittal, Bergen, Pearson Education.

Paper Name: Power Quality
Paper Code: PSM103C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Power System, and Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Understand the Power Quality problems in power system.
- **CO2.** Analyze the causes of the Power Quality issues.
- **CO3.** Design the controllers for mitigating the Power Quality issues in power system.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	3
CO2	3	3	3	2	2
CO3	3	3	2	2	2

Course Content

Module 1: Electric power quality phenomena **5L**
Impacts of power quality problems on end users, Power quality standards, power quality monitoring.

Module 2: Power quality disturbances **6L**
Transients, short duration voltage variations, long duration voltage variations, voltage imbalance, wave-form distortions, voltage fluctuations, power frequency variations, power acceptability curves.

Module 3: Power quality problems **5L**
Poor load power factor, loads containing harmonics, notching in load voltage, dc offset in loads, unbalanced loads, disturbances in supply voltage.

Module 4: Transients **4L**
Origin and classification- capacitor switching transient-lighting-load switching-impact on users-protection mitigation.

Module 5: Harmonics **7L**
Harmonic distortion standards, power system quantities under non sinusoidal conditions harmonic indices-source of harmonics-system response characteristics-effects of harmonic distortion on power system apparatus –principles for controlling harmonics, reducing harmonic currents in loads, Filtering, modifying the system frequency response- Devices for controlling harmonic distortion, inline Reactors or chokes, zigzag transformers, passive filters, active filters.

Module 6: Power quality conditioners **9L**
Various theories used for analysis, design and modeling of power quality conditioners, Shunt and series compensators, DSTATCOM-dynamic voltage restorer, unified power quality conditioners.

Text Books:

1. Ghosh Arindam and Ledwich Gerard, “Power quality enhancement using custom power

devices” Springer.
2. Arrillaga J., Watson N. R. and Chen S., “Power System Quality Assessment” Wiley.
3. Angelo Baggini “Handbook of Power Quality” – Wiley.
4. Caramia P, Carpinelli G and Verde P, “Power quality indices in liberalized markets”– Wiley.

Reference Books:

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, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997.

Paper Name: High Voltage Transmission System
Paper Code: PSM103D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power Systems, Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate the transmission of EHV AC and HVDC with their electrical and mechanical design.
- **CO2.** Analyze the Performance and Efficiency of Transmission Lines, Efficiency in Transmission Line as well as Field calculation by finite difference method with equal and unequal nodal distance in 2-D and 3-D system.
- **CO3.** Demonstrate the Power Electronic Converters for HVDC transmission system with their characteristics.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	2	-	3	2
CO2	3	3	2	3	3
CO3	3	2	-	2	3

Course Content

Module 1: **4L**
High voltage transmission line trends and preliminary aspects of standard transmission voltages. Comparison between HVAC and HVDC transmission, planning for HVDC transmission, links, properties of HVDC thyristor valves, components of HVDC transmission system.

Module 2: **10L**
HVDC converters: 6 pulse converter circuits and working principle, converter bridge characteristics, working principle and characteristics of a twelve-pulse converter with two & three valve conduction mode, three valve conduction mode and three and four valve conduction mode.

Module 3: **10L**
Mechanism of AC Power Transmission, Principle of Control, Necessity of Control in DC Link, Constant Current vs Constant Voltage, Current Margin Control Method, Firing Angle Control, Pulse Phase Control, Stability of Control, Compounding of Rectifier, Power Reversal in a DC Link, Voltage Dependent Current Order Limit Characteristics of the Converter, Starting and Stopping of DC Link, Constant Power Control, Control Systems for HVDC Converters.

Module 4: **8L**
Important of Harmonic Study, Generation of Harmonics by Converters, Characteristics and Non characteristics Harmonics, Trouble caused by Harmonics, Wave Distortion or Ripple, Characteristics Variation of Harmonic Currents with Variation of Firing and Overlap Angle, Harmonic Filter.

Module 5: **4L**
Faults on AC Side and DC side of System, Protection against Overcurrent/Overvoltage, Protection of Filter Units.

Text Books:

1. Rakosh Das Begamudre, “Extra high voltage ac transmission engineering” New Age International Publisher. Power System Stability & Control, By- P. Kundur, Tata McGraw hill.
2. Padiyar K. R. “HVDC transmission systems” Wiley.

Reference Books:

1. Arrilaga, J. “High voltage direct current transmission” Peter Pereginver Ltd, London.

Paper Name: Renewable Energy Systems and Microgrid
Paper Code: PSM104A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power Systems, Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Explain different types of renewable energy generation.
- **CO2.** Demonstrate impact of renewable energy sources on grid and its integration.
- **CO3.** Illustrate different protection schemes of distributed generation.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	2	-	3	3
CO2	3	3	2	3	3
CO3	3	2	-	2	3

Course Content

Module 1: **6L**
Introduction, Distributed vs Central Station Generation, Sources of Energy such as Micro-turbines, Internal Combustion Engines.

Module 2: **7L**
Introduction to Solar Energy, Wind Energy, Combined Heat and Power, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass and Fuel Cells.

Module 3: **5L**
Power Electronic Interface with the Grid.

Module 4: **6L**
Impact of Distributed Generation on the Power System, Power Quality Disturbances.

Module 5: **6L**
Transmission System Operation, Protection of Distributed Generators.

Module 6: **6L**
Economics of Distributed Generation, Case Studies.

Text Books:

1. Ranjan Rakesh, 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.

Reference Books:

1. Roger A. Messenger, Jerry Ventre, “Photovoltaic System Engineering”, 3rd Ed, 2010.

Paper Name: Advanced Converter Technology
Paper Code: PSM104B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Knowledge of Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Describe the characteristics of PSDs and their applications.
- **CO2.** Analyze the working of multi-level VSIs, DC-DC switched mode converters, cyclo-converters and PWM techniques and the ability to use them properly.
- **CO3.** Illustrate the power conditioners and their applications.
- **CO4.** Design power circuit and protection circuit of PSDs and converters.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	3
CO2	3	2	-	3	2
CO3	3	2	2	2	3
CO4	3	2	1	3	2

Course Content

Module 1: Overview of Switching Power Devices **6L**
Static and dynamic characteristics of switching devices: BJT, MOSFET, IGBT, GTO, GaN. Design of driver and snubber circuit, Series and parallel operation of switching devices.

Module 2: Phase-Controlled Rectifiers **7L**
Overview on different topologies of single-phase and three-phase controlled rectifiers, Effect of source inductance, overlap angle, THD analysis, Concept of distortion factor and input power factor.

Module 3: DC-DC Converters **8L**
Non-isolated DC-DC converters: buck- boost- buck-boost, CUK converters under continuous and discontinuous conduction operation. Isolated DC-DC converters: forward fly-back, push-pull, half-bridge and full-bridge converters. Relationship between input and output voltages, expression for filter inductor and capacitors, High gain DC-DC converters.

Module 4: Inverters **8L**
Single-phase and three-phase inverters, PWM techniques: single, multiple, and sinusoidal PWM techniques, selective harmonic elimination, space vector modulation, current source inverter, multi-level inverters: Diode-clamped, cascaded and Flying capacitor types, concept of active Filters.

Module 5: Front-End (AC-DC) Converters **7L**
PWM rectifiers: configuration types, three-phase full and semi converters, reactive power, power factor improvements, extinction angle control, symmetrical angle control, PWM control.

Text Books:

1. M.H. Rashid: Power Electronics-circuits, Devices & Applications, 3rd ed., PHI 2005.
2. N Mohan, T. M. Undeland, W. P. Robbins: Power Electronics: Converters, Applications,

3rd ed., John Wiley & Sons, 2009.

Reference Books:

1. Umanand, L., Power Electronics: Essentials and Applications, chapters 1 to 7, John Wiley, India, 2009.
2. Jayant Baliga B, Power Semiconductor Devices, PWS 1996.

Paper Name: Dynamics of Electrical Machines
Paper Code: PSM104C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Electrical Machines.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Describe transformation of reference frames pertaining to electrical machines.
- **CO2.** Illustrate generalized model of DC machines, Induction machines and Synchronous machines.
- **CO3.** Analyze steady-state operating conditions of DC machines, Induction machines and Synchronous machines.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	2
CO2	3	2	3	2	3
CO3	3	2	2	3	2

Course Content

Module 1: Elements of generalized theory **6L**
Kron's primitive machine, Transformation from three phase to two phase (abc to αβ0), Transformation from Rotating axes (αβ0) to stationary axes (dq0), Physical concepts of park's transformation, Transformed impedance Matrix.

Module 2: D.C. Machines **12L**
Separately excited D.C. generators, separately excited D.C. Motors, Transfer function of D.C. Machines, D.C. Series Motors, D.C. Shunt Machines, D.C. Compound Machines, Linearization Techniques for small perturbations, Cross field Machines.

Module 3: Ploy phase Induction Machines **9L**
Transformation, Electrical performance equations, Analysis of the equivalent circuit, Torque-slip characteristics, Effect of voltage & frequency variation on the Induction Motor performance.

Module 4: Poly phase Synchronous Machines **9L**
Basic Synchronous Machines parameters, General Machine's equations, Three phase Synchronous Machines (with no Amortisseurs), Balance steady – state analysis, Steady-state power-angle characteristics.

Text Books:

1. Generalized theory of Electrical machines, P. S. Bimbhra, Khanna publishers.
2. Matrix Analysis of Electrical Machines, A. K. Mukhopadhyay, New Age International.
3. Electrical Machinery, S.K. Sen, Khanna Publishers.
4. Electric motor drives, modeling, analysis and control, R. Krishnan, PHI

Reference Books:

1. Modern power electronics and AC drives, B.K. Bose, Pearson education.
2. Power system stability, Vol-III, E. W. Kimbar, John Wiley & Sons.
3. Electrical Machinery, A.E. Fitzgereld, C. Kingslay and S.D. Uman, McGraw Hills.

Paper Name: Electric Power Market Operations
Paper Code: PSM104D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics, Power System Analysis.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** To model the market structure.
- **CO2.** To inform in real time the spot pricing.
- **CO3.** To analyze and minimize the congestion in power system.
- **CO4.** To promote and analyze the effects of ancillary services.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	3	3
CO2	3	3	3	2	-
CO3	1	-	2	-	3
CO4	3	3	2	3	2

Course Content

Module 1: **6L**

Fundamentals of electricity markets: Market structure and operating mechanisms, bilateral and multi-lateral markets. Perfect Competition, Oligopolistic Market, Theories of Oligopoly, Market Types-Commodity, Power, Energy, Ancillary Services, Transmission.

Module 2: **9L**

Modelling, operation and analysis of electricity markets, Market Equilibrium, Market Structure, Formulation of the market, Price formulation and drivers, Merit order, Carbon markets (emission rights), Impact of renewables, Mean reversion & Seasonality, Cross-border transmission capacity, Market participants (producers, suppliers, TSOs), Exchange members, Dispatch & asset-backed trading, Balancing, Intraday / prompt markets, Market coupling, Day ahead markets & Daily auctions, Hedging, Forward markets & the application of power futures.

Module 3: **8L**

Electricity Markets Pricing: Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow, Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices.

Module 4: **8L**

Power system operation in restructured markets: Coordinated real time dispatch through balancing mechanism, Imbalance settlement methodologies. Transmission Congestion Management and Methodologies, Congestion Pricing, Effect of congestion on LMPs, Transmission Losses, Limits and Congestion, Country Practices, Dynamic Congestion Management. Available Transfer Capability Evaluation and Methodologies- market splitting, counter-trading. New Unit Commitment Price based OPF in restructured markets.

Module 5: **5L**

Ancillary Services: Classifications and definitions, Market for AS, AS management in various markets, Forward AS auction, country practices, Contingency reserves: Pricing and procurement, Voltage security and reactive power management.

Text Books:

1. M. Shahidehpour, H. Yamin, and L. Zuyi, "Market Operations in Electric Power Systems". New York: Wiley, 2002.
2. Yong-Hua Song and Xi-Fan Wang (Eds.), "Operation of Market-oriented Power Systems", Springer Verlag London Limited, 2003.
3. D. S. Kirschen and G. Strbac, "Fundamentals of power system economics", John Wiley & Sons, 2004.

Reference Books:

1. K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, "Operation of restructured power systems", Kluwer Academic Publishers, 2001.

Paper Name: Power System Optimization Laboratory
Paper Code: PSM191
Contact: 0L:0T:3P
Credit: 1.5

Prerequisites: Engineering Mathematics, Power System, Control System.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Apply various type of optimization techniques for economic power generation.
- **CO2.** Demonstrate economic load dispatch.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	2	-	2	3
CO2	2	2	3	-	2

List of experiments to be done through simulation:

1. Calculation of the generator powers while minimizing the costs subject to the linear constraints.
2. Calculation of the generator powers while minimizing the costs subject to the non-linear constraints.
3. Dynamic response of a mechanical or electrical system.
4. Calculation of the Generator Shift factors or Sensitivity matrix (PTDF) matrix.
5. Unit Commitment solution methods.
6. Lambda iteration method optimization (Krash-Kuhn-Tucker method)
7. Economic Load Dispatch Problem.
8. Multi Machine Transient Stability Problem.
9. Load dispatch and Reactive power constraints.
10. ATC Calculation in a six-bus system.
11. Congestion Management and Power System Security calculations using the constraints.
12. Locational Marginal Price calculation in a multi bus system.

Paper Name: Power System Steady State Analysis Laboratory
Paper Code: PSM192
Contact: 0L:0T:3P
Credit: 1.5

Prerequisites: Electrical Machines and Power Systems.

Course Outcomes: After the completion of the course, the student will be able to

CO1. Formulate different techniques of load flow studies.
CO2. Analyze system voltage stability.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	3
CO2	2	2	2	-	3

List of experiments:

1. Develop MATLAB program for transient stability analysis for single machine connected to infinite Bus.
2. To plot P-V, Q-V curves for voltage stability analysis.
3. Develop MATLAB program for G-S load flow analysis.
4. Develop MATLAB program for N-R load flow analysis.
5. Develop MATLAB program for FD load flow analysis.
6. Develop MATLAB program for the analysis of voltage security.
7. Develop MATLAB program for the solution of swing equation.
8. Develop MATLAB program for Y-Bus Matrix formation for N-Bus Systems.
9. Develop MATLAB program for Y-Bus formation with Tap changing transformers.
10. Modeling and simulation of synchronous machine with FACTS devices for Power Factor improvement.

2nd Semester								
Sl. No.	Core / Elective	Paper Code	Subject	Contact Hours/Week				Credit Points
				L	T	P	Total	
A. THEORY								
1	Core 3	PSM201	Power System Operation and Control	3	0	0	3	3
2	Core 4	PSM202	Digital Protection of Power System	3	0	0	3	3
3	PE 3	PSM203	E. Power System Transient F. Smart Grid Technology G. Flexible A.C. Transmission System H. Restructured Electric Power Systems	3	0	0	3	3
4	PE 4	PSM204	E. Advanced Control System F. Modeling and Simulation of Dynamic Systems G. Advanced Microprocessor and Microcontroller H. Electric and Hybrid Vehicles	3	0	0	3	3
B. PRACTICAL								
5	Lab 3	PSM291	Advanced Power System Protection Laboratory	0	0	3	3	1.5
6	Lab 4	PSM292	Power Quality Laboratory	0	0	3	3	1.5
C. SESSIONAL								
7	Project 1*	PSM205	Research Methodology	0	0	0	0	2
8	Project 2	PSM281	Seminar	0	0	0	0	2
Total of Theory, Practical and Sessional							**18**	**19**

* Student should complete at least one MOOC course related to Research Methodology.

Paper Name: Power System Operation and Control
Paper Code: PSM201
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Electrical Machines.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Describe transformation of reference frames pertaining to electrical machines.
- **CO2.** Illustrate generalized model of DC machines, Induction machines and Synchronous machines.
- **CO3.** Analyze steady-state operating conditions of DC machines, Induction machines and Synchronous machines.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	3
CO2	3	2	3	-	3
CO3	3	2	2	3	2

Course Content

Module 1: Optimal Generation Scheduling 11L
Power flow scheduling using economic load dispatch, power flow scheduling using Lagrange multiplier method, penalty factor, scheduling with network losses, hydrothermal coordination with and without losses, cascaded and pump storage plant scheduling, unit commitment, unit commitment solution methods, introduction to optimal power flow solution using Newton Raphson method.

Module 2: Automatic Generation Control 9L
Types of alternator exciters, automatic voltage regulators for generator excitation control, static and dynamic performance of AVR loop, automatic load frequency control, primary automatic load frequency control loop, secondary automatic load frequency control loop, extension of automatic load frequency control loop to multi area systems, tie line power flow model.

Module 3: Power System Security 5L
Security analysis, security assessment, contingency analysis, algorithm to determine system security following contingency analysis procedure, security assessment using ac power flow model, security analysis using concept of performance index.

Module 4: State Estimation and load forecasting 11L
Methods of state estimation – least square and weighted least square estimation, bad data detection and suppression of bad data, load forecasting, load forecasting techniques – methods of extrapolation and correlation, estimation of average and trend terms of deterministic part of load – limitation of the method, prediction of deterministic load, generalized load modeling, estimation of periodic components, estimation of stochastic part of load – time series approach.

Text Books:

1. 1. Modern Power System Analysis – D. P. Kothari, I. J. Nagrath, TMH Publication.
2. An introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems – A Chakrabarti, D P Kothari, A K Mukhopadhyay, Abhinandan De, PHI.
3. Power System Analysis – J. J. Grainger, W.D. Stevenson, Mc-GrawHill series publication.

4. Electrical Power Systems – P. Venkatesh, B.V. Manikandan, S.C. Raja, A. Srinivasan, PHI.
5. Power Generation Operation and Control – A. J. Wood, B. F. Woolenberg, John Wiley and Sons.

Reference Books:

1. Power System Analysis – Hadi Saadat, Mc-GrawHill series publication.
2. Advanced Power System Analysis and Dynamics – L. P. Singh, New Age International.
3. Operation of Restructured Power Systems – K. Bhattacharya, H. J. Bollen, J. E. Daalder, Kluwer academic publishers.

Paper Name: Digital Protection of Power System
Paper Code: PSM202
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of mathematics, Physics and Basic Electrical Engineering.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Define the importance of Digital Relays.
- **CO2.** Apply Mathematical approach towards protection.
- **CO3.** Distinguish various Protection algorithms.
- **CO4.** Simulate protection for abnormalities in virtual environment.
- **CO5.** Demonstrate primitive relays at contingency state.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	2
CO2	3	3	-	3	3
CO3	3	2	2	2	-
CO4	-	-	3	2	3
CO5	2	3	3	3	2

Course Content

Module 1: **5L**
Evolution of digital relays from electromechanical relays, performance and operational characteristics of digital protection.

Module 2: **5L**
Mathematical background to protection algorithms, finite difference techniques.

Module 3: **7L**
Interpolation formulae, forward, backward and central difference interpolation, numerical differentiation, curve fitting smoothing, least squares method, Fourier analysis, Fourier series and Fourier transform and Walsh function analysis.

Module 4: **7L**
Basic elements of digital protection, signal conditioning: transducers, surge protection, analog filtering analog multiplexers conversion subsystem: the sampling theorem. signal aliasing, error, sample and hold circuits, multiplexers, analog to digital conversion, digital filtering concepts, the digital relay as a unit consisting of hardware and software.

Module 5: **6L**
Sinusoidal wave based algorithms, sample and first derivative (Mann and Morrison) algorithm, Fourier and Walsh based algorithms.

Module 6: **4L**
Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm, Walsh function based algorithm, Least Squares based algorithms, differential equation based algorithms.

Text Books:

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

Reference Books:

1. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press, 1999.

Paper Name: Power System Transient
Paper Code: PSM203A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power Systems.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Knowledge of various transients that could occur in power system and their mathematical formulation.
- **CO2.** Ability to design various protective devices in power system for protecting equipment and personnel.
- **CO3.** Coordinating the insulation of various equipment's in power system.
- **CO4.** Modelling the power system for transient analysis.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	3
CO2	3	2	-	3	2
CO3	3	2	2	2	3
CO4	-	3	3	3	-

Course Content

Module 1: Introduction and survey **6L**
Review of various types of power system transients – effect of transients on power systems relevance of the study and computation of power system transients.

Module 2: Lighting surges **7L**
Electrification of thunderclouds – lightning current surges – lightning current parameters and their values – stroke to tower and midspan – induced lightning surges.

Module 3: Switching surges **8L**
Closing and reclosing of lines – load rejection – fault initiation – fault clearing – short line faults – Ferro – resonance – isolator switching surges – temporary over voltages – surge on an integrated system – switching – harmonics.

Module 4: Computation of transient in conversion equipment **7L**
Travelling wave method – Beweley's Lattice diagram – analysis in time and frequency domain – eigen value approach – Z-transform – EMTP software.

Module 5: Insulation coordination **8L**
Over voltage protective devices – shielding wires, rods gap and surge diverters, principles of insulation coordination-recent advancements in insulation coordination – design of EHV system.

Text Books:

1. "Transients in Power Systems", by Lou van der Sluis, John Wiley & Sons, Ltd, Chic ester, UK 2002.
2. "Power System Transients: Theory and Applications", by Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, CRC Press 2013.
3. "Electrical Transients in Power Systems", by Allan Greenwood, Wiley-Interscience; 2nd edition, April 1991.

References Books:

1. "Power System Transients: A Statistical Approach", by C.S Indulkar, D.P. Kothari, K. Ramalingam, PHI, 2nd edition, 2010.
2. "Electrical Transients in Power Systems", by Allan Greenwood Wiley India Private Limited; Second edition, July 2010.

Paper Name: Smart Grid Technology
Paper Code: PSM203B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics, Power Systems, Control Systems.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Understand the features of Smart Grid.
- **CO2.** Assess the role of automation and digitization in Transmission Distribution.
- **CO3.** Analyze Smart grids and Distributed energy resources (DER) with Evolutionary algorithms.
- **CO4.** Understand operation and importance of data acquisition devices and their location in voltage and Frequency control.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	3	3	2	3
CO2	3	1	2	1	2
CO3	2	2	2	3	-
CO4	1	3	3	2	3

Course Content

Module 1: Introduction to Smart Grid **7L**

Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, smart-grid activities in India.

Module 2: Smart Grid Architecture **9L**

Smart grid architecture, standards-policies, smart-grid control layer and elements, network architectures, IP-based systems, power line communications, supervisory control and data acquisition system, advanced metering infrastructure.

Module 3: **11L**

Computational Techniques – Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch – Computational Intelligence Techniques – Evolutionary Algorithms in power system – Artificial Intelligence techniques and applications in power system. Distribution Generation Technologies Introduction to Distribution Energy Sources, Renewable Energy Technologies – Microgrids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change –Economic Issues.

Module 4: **9L**

Introduction to Communication Technology, Two Way Digital Communications Paradigm, Synchro Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IoT)- Applications of IoT in Smart Grid.

Text Books:

1. S. Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 1st Edition, 2013.
2. G. Masters, “Renewable and Efficient Electric Power System”, Wiley–IEEE Press, 2nd Edition, 2013.

References Books:

1. A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer, 2nd Edition, 2017.
2. T. Ackermann, "Wind Power in Power Systems", Hoboken, N J, USA, John Wiley, 2nd Edition, 2012.

Paper Name: Flexible AC Transmission System
Paper Code: PSM203C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power System and Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
- **CO2.** Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled.
- **CO3.** Reactive Power Systems, PWM Inverter based Reactive Power Systems and their controls.
- **CO4.** To develop analytical modeling skills needed for modeling and analysis of such Static VAr Systems.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	2
CO2	3	2	-	3	1
CO3	3	2	2	2	3
CO4	2	3	3	3	2

Course Content

Module 1: Introduction **7L**
FACTS – a toolkit, basic concepts of static VAr compensator, Resonance Damper, thyristor-controlled series capacitor, static condenser, phase angle regulator and other controllers.

Module 2: Series compensation schemes **7L**
Sub-synchronous resonance, torsional interaction, torsional torque, compensation of conventional, ASC, NGH damping schemes, modeling and control of thyristor-controlled series compensators.

Module 3: Unified power flow control **9L**
Introduction, Implementation of power flow control using conventional thyristors, Unified power flow concept, Implementation of unified power flow controller. Phasor Monitoring Units; Power System Control using Synchro phasors.

Module 4: Design of facts controllers **7L**
Approximate multi-model decomposition, variable structure FACTS controllers for power system transient stability, non-linear variable-structure control, variable structure series capacitor control and variable structure resistor control.

Module 5: Static var compensation **6L**
Basic concepts, thyristor-controlled reactor (TCR), Thyristor Switched Reactor (TSR), Thyristor Switched capacitor (TSC), saturated reactor (SR), fixed capacitor (FC).

Text Books:

1. Narin G. Hingorani, Flexible AC transmission, IEEE Spectrum, April 1993, pp 40-45.
2. Narin G. Hingorani, High Power Electronics and flexible AC Transmission systems, IEEE High Power Engineering Review, 1998.

3. Narin G. Hingorani, Power Electronics in Electric Utilities: Role of Power Electronics in future power systems, Proc. of IEEE, IEEE, Vol.-76, No.-4, April 1988.

Reference Books:

1. Einar V Larsen, Juan J. Sanchez-Gasca, Joe H. Chow, Concepts for design of FACTS Controllers to damp Power Swings, IEEE Trans on Power Systems, Vol.-10, No.-2, May 1995.
2. Gyugyi L., Unified Power Flow Control Concept for Flexible Ac Transmission, IEEE Proc-C Vol.-139, No.-4 July 1992.

Paper Name: Restructured Electric Power Systems
Paper Code: PSM203D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Power Systems, Mathematical Programming.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Identify various concepts of restructuring and deregulation of power sector.
- **CO2.** Describe important concepts related with deregulation like market power, OASIS, congestion management etc.
- **CO3.** Apply principal to explain various problems related with deregulation of power sector.
- **CO4.** Assess the results obtained by solving above problems.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	2
CO2	3	-	2	3	3
CO3	3	3	2	3	-
CO4	3	3	2	3	3

Course Content

Module 1: Introduction 5L
Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.

Module 2: Power System Restructuring 5L
An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.

Module 3: Deregulation of Power Sector 5L
Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model.

Module 4: Competitive electricity market 7L
Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing.

Module 5: Open Access Same Time Information System (OASIS) 6L
Introduction, structure, functionality, implementation, posting of information, uses.

Module 6: Congestion Management 8L
Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC).

Module 7: Different Experiences in deregulation 9L
U.S.A, Canada, U.K, Japan, Switzerland, Australia, Sweden, Germany and Indian power system.

Text Books:

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, Muwaffaq Alomoush, "Restructured electrical power systems: operation, trading and volatility", Marcel Dekker.

Reference Books:

1. Power System Restructuring and Deregulation by Loi Lei Lai, John Wiley & Sons Ltd.
2. Understanding Electric Utilities and Deregulation by Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York, CRC Press.
3. Power System Restructuring Engineering & Economics by Marija llic by Francisco Galiana and Lestor Fink, Kulwer Academic Publisher, USA.

Paper Name: Advanced Control System
Paper Code: PSM204A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Control Systems.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Apply the concepts of linear algebra and their applications to control system.
- **CO2.** Analyze the system dynamics and Lyapunov stability theory.
- **CO3.** Design linear quadratic controller.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	3
CO2	3	2	1	3	2
CO3	3	2	2	3	1

Course Content

Module 1: Overview of Control Systems **6L**
LTI Motion Control System; Temperature & Voltage Regulators; Modeling of Servo-motors, Hydraulic & pneumatic actuators. Computation of Relative stability using Bode plot and Nyquist method. Hierarchical Control of Power System; System Control; Load scheduler and Optimizer; Real Reactive Power Flow Control; AVR and Turbine Speed governor set points.

Module 2: Control System Performance **5L**
Improvement of System Performance through Compensation; Design of lag; Lead and Lag Load Compensators; PI, PD & PID control; PID Controller Design and tuning; Disturbance rejection; System Uncertainty and performance Robustness.

Module 3: Analysis in state space **6L**
State model for SISO & MIMO Systems; State Diagram; Solution of state equation; State Transformations; Jacobian Linearization Technique; Stability; Controllability & Observability; Perspective on State-Space design; Full-State Feedback Design of continuous time control system; Full Order Observer System.

Module 4: Digital Control system **9L**
Configuration of Digital Control System; Supervisory Control; Direct digital control; Single-Loop Digital controllers; Sampling Process; Sampling theorem; Data reconstruction; Digital transfer function & System response; Stability Tests; Mapping between s-plane & z-plane; Bilinear transformation; Error constants; Pole assignment design based on full state feedback; Compensator design in w-plane using Bode plot.

Module 5: Non-linear System **5L**
Common non-linearities; Methods of Analysis; Linearization; Phase Plane method; Describing function Analysis; Limit Cycles; Relay with dead-zone and hysteresis; Stability analysis by Lyapunov’s methods.

Module 6: Optimal Control **5L**
Characteristics of optimal control problems; Linear optimal Control with quadratic performance index; Selection of performance measure; State and Output regulators; Optimal state regulator

problem with matrix Ricatti equation.

Text Books:

1. Ogata, k – modern control engineering, p.h learning.
2. Kuo, b.c – automatic control systems, prentic hall.
3. Roy chowdhury, d – modern control engineering, prentic hall.
4. Nagrath i.j, gopal m – control system engineering, new age publishing.
5. Gopal, m – digital control and state variable methods, tata mcgraw -hill.

Reference Books:

1. Kuo, b.c. – digital control system, oxford university press.
2. Franklin f, powell j.d, emami naeini, a- feedback control of dynamic systems, addision weslay publication.
3. Peter dorato – robast control.
4. Gibson, j.e. – non-linear system, mcgraw –hill.

Paper Name: Modelling and Simulation of Dynamic Systems
Paper Code: PSM204B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Engineering Mathematics, Power System, Control System.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Explain the dynamic model.
- **CO2.** Select the appropriate model on which analysis to be done.
- **CO3.** Analyze the performance of the system with small signal analysis.
- **CO4.** Explain the controllers and their significance in power system.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	3	2
CO2	3	1	2	-	3
CO3	2	2	-	3	3
CO4	1	3	3	2	-

Course Content

Module 1: 6L
Linearized System Equations, System with nonlinear equations, Linear System from Mathematical view point, General properties of linear differential equation, linear equations of first order, Higher order linear equations with constant coefficient, Simultaneous differential equation.

Module 2: 7L
Simple Model of Synchronous generator, Steady state model of synchronous generator, Exciter Model, Governor model, Turbine model, Stabilizer model, Model of Tap changing and Two winding transformer, Model of Phase shifting transformer, Model of Long and Medium Transmission Lines, Modelling of Shunt Capacitor and Inductor, Modelling of Induction Motor, SVC, STATCOM, SPS, IPC, UPFC.

Module 3: 7L
Power Flow in a two terminal transmission network, Receiving end power circle diagram, Reactive power requirement of an uncompensated line, Surge Impedance Loading, Line Load ability, Operation of a transmission line under heavy loading condition, Relation of voltage regulation with reactive power, Midpoint condition of a transmission line.

Module 4: 8L
Approximate Representation of a transmission line in transient study, Concept of Infinite line, Propagation, Attenuation and Phase Shift Constant of a transmission line, Wavelength and Velocity Propagation, Reflection of resistive load, Reflection of Terminal Inductance, Bus Admittance and Bus Impedance Matrix, SLFE Equations, G-S Methods in a multibius system, N-R method, Node Elimination and Triangular Factorization, Decoupled, FDLF, DC Load flow methods.

Module 5: 8L
Mathematical concept of stability, Transient stability, Linearization of swing equation, Equal Area Criterion, Reactive power and Voltage Control, Voltage Collapse Mechanism, Voltage Security, Small signal stability modeling of a single machine, Infinite bus system, SMIB with applications, Small Signal Stability in Multi machine power system, Power System compensation using FACTS

devices.

Text Books:

1. Power System Dynamics Stability and Simulation by A. Chakraborty, PHI
2. Power System Stability & Control, By- P. Kundur, Tata McGraw hill.

Reference Books:

1. Power Systems Analysis by Vijay Vittal, Bergen, Pearson Education.

Paper Name: Advanced Microprocessor and Microcontroller
Paper Code: PSM204C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Microprocessor and Microcontroller.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Explain architectures of microprocessors and microcontrollers.
- **CO2.** Develop different waveforms.
- **CO3.** Design digital protection schemes for power system network.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	3
CO2	3	2	3	-	2
CO3	-	2	2	3	1

Course Content

Module 1: Introduction **3L**
Review of Intel 8085 and 8086 – Architecture and Organization.

Module 2: Components and functions **9L**
Execution Unit, Bus Interface Unit, Registers, Minimum and Maximum Mode of Operation, Bus Arbiter, Interrupt Structure, Interrupt Vector Table, I/O Ports, Experimental identification of Ports and Pins.

Module 3: Peripheral devices **4L**
PPI 8255, Mode 0, Mode 1, Mode 2 and BSR Mode. Interrupt Controller, DMA Controller, ADC, DAC.

Module 4: Development of waveforms **3L**
Square, Triangular, Ramp, Staircase, Sinewave

Module 5: Relays **4L**
Microprocessor based Electromagnetic Relays, IDMT, Differential Relay.

Module 6: Instrumentation & protection (smart grid) **10L**
Microprocessor based Voltage, Current, Power and Speed measurement, Frequency Monitoring, Overvoltage, Undervoltage, Overcurrent and Undercurrent protection, Speed Control of Motors, Traffic Light Controller, Washing Machine Controller.

Module 7: Microcontroller **3L**
Architecture, Organization and Programming Techniques.

Text Books:

1. A. K. Mukhopadhyay - Microprocessor, Microcontroller and their Applications, Narosa Publishing / Alpha Publication, Oxford University.
2. Microprocessor and Microcontroller – Gaonkar.

Reference Books:

1. A. K. Mukhopadhyay – Microprocessor based Laboratory experiments and Projects, I. K. International.
2. Anokh Singh, A. K. Chhabra - Fundamentals of Microprocessors and its Applications, S. Chand Publishers.

Paper Name: Electric and Hybrid Vehicles
Paper Code: PSM204D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Electric Drives.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Select a suitable drive scheme for developing an electric hybrid vehicle depending on resources.
- **CO2.** Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
- **CO3.** Choose proper energy storage systems for vehicle applications.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	3	2	2	-	3
CO3	-	2	2	3	2

Course Content

Module 1: Electric Vehicles **8L**
Introduction, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design.

Module 2: Battery **9L**
Basics – Types, Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Battery pack Design, Properties of Batteries.

Module 3: DC & AC Electrical Machines **6L**
Motor and Engine rating, Requirements, DC machines, three phase AC machines, Induction machines, permanent magnet machines, switched reluctance machines.

Module 4: Electric Vehicle Drive Train **6L**
Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing.

Module 5: Hybrid Electric Vehicles **7L**
Types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components.

Text Books:

1. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press, 2011.
2. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
2. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000.

Paper Name: Advanced Power System Protection Laboratory
Paper Code: PSM291
Contact: 0L:0T:3P
Credit: 1.5

Prerequisites: Power Systems.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate different types of power system protection scheme.
- **CO2.** Implement relay applications to the power system protection.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	-	2
CO2	2	2	2	2	3

List of Experiments:

1. Testing of CT and PT.
2. Development of Differential protection scheme using Disc type over current relay.
3. Testing of On load and Off load time delay relay.
4. Testing of under voltage relay.
5. Testing of numerical Distance relay.
6. Study of generator protection scheme using instantaneous differential relay.
7. Study of transformer protection using differential relay.
8. Study of over-current and earth fault relay.
9. Study of Microprocessor based relay.

Paper Name: Power Quality Laboratory
Paper Code: PSM292
Contact: 0L:0T:3P
Credit: 1.5

Prerequisites: Power Systems, Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

CO1. Explain the effect of nonlinear loads to the power supply.
CO2. Identify different type of sources which affect power quality.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	-	3
CO2	2	3	2	2	3

List of Experiments:

1. To study the effect of nonlinear loads on power quality.
2. To demonstrate the voltage and current distortions experimentally.
3. To reduce the current harmonics with filters.
4. To study the voltage sag due to starting of large induction motor.
5. To study the capacitor switching transients.
6. To study the effect of balanced nonlinear load on neutral current, in a three phase circuit
7. To study the effect of ground loop.
8. To study the effect of voltage flicker.
9. To calculate the distortion power factor.
10. Study the effect of harmonics on energy meter reading
11. To study effect of voltage sag on electrical equipment.
12. To obtain the current harmonics drawn by power electronics interface.

3rd Semester									
Sl. No.	**Core / Elective**	**Paper Code**	**Subject**	**Contact Hours/Week**				**Credit Points**
				L	**T**	**P**	**Total**	
A. THEORY								
1	PE 5	PSM301	A. Dynamics of Linear Systems B. Energy Control Center – Concept and Implementation C. Advanced Digital Signal Processing D. AI Techniques	3	0	0	3	3
2	OE 1	PSM302	A. Business Analytics B. Industrial Safety C. Operations Research D. Cost Management of Engineering Projects	3	0	0	3	3
B. SESSIONAL								
3	Project 3	PSM 391	Dissertation (Phase – I)	0	0	20	20	10
Total of Theory, Practical and Sessional							**26**	**16**

Paper Name: Dynamics of Linear Systems
Paper Code: PSM301A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Control Systems.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate mathematical modelling, state space representation and basics of linear vector space.
- **CO2.** Explain Canonical realizations and similarity transformation.
- **CO3.** Analyze Time response and System Stability.
- **CO4.** Analyze Controllability and observability of a system.
- **CO5.** Estimate State feedback and State estimation.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	3
CO2	2	-	2	2	2
CO3	3	2	-	3	-
CO4	-	2	3	-	3
CO5	3	3	2	3	2

Course Content

Module 1: Mathematical modelling and basics of linear spaces 6L
Mathematical descriptions: transfer function and state-space, state space representation of electrical and mechanical systems, some basics of linear vector space: vector space, basis, linear dependent, matrix representation.

Module 2: Canonical realizations and similarity transformation 9L
Controller canonical realization, observer canonical realization, diagonal realization, analog computer simulation, non-uniqueness of state-space representation, transformation to diagonal form, Jordan form, controller canonical form and observer canonical form.

Module 3: Time response and stability 6L
Time response of linear systems, modal analysis (associated with eigenvalues and eigenvectors), stability analysis: external and internal stability, Ackerman's Formula - stabilization by output feedback.

Module 4: Controllability and observability 8L
Controllability and observability matrices, rank test, controllable and uncontrollable modes, matrix decomposition corresponding to controllable and uncontrollable modes, asymptotic observers for state measurement, observer design.

Module 5: State feedback and state estimation 7L
State feedback, pole assignment, state estimation, observer design, combined controller-observer design.

Text Books:

1. T. Kailath, Linear Systems, Englewood Cliffs, Prentice-Hall, Englewood Cliffs, NJ, 1980.

Reference Books:

1. P.J. Antsaklis and A.N. Michel, Linear Systems, McGraw-Hill, Englewood Cliffs, NJ, 1997,
2. K. Ogata, Modern Control Engineering, Prentice-Hall, NJ, 2010.

Paper Name: Energy Control Center – Concept and Implementation
Paper Code: PSM301B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Electrical Machines, Power System and Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate different type of energy sources, its grid integration.
- **CO2.** Illustrate utilization of energy sources through demand side management
- **CO3.** Explain energy control center as per standards and acts associated.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	3
CO2	3	2	2	3	3
CO3	3	2	2	3	3

Course Content

Module 1: Introduction 4L
Energy Scenario – global, sub continental and Indian, Energy economy relation, Future energy demand and supply scenario, Integrated energy planning with particular reference to Industrial Sector in India, Captive power units and others – demand v/s supply.

Module 2: Types of Energy 4L
Physical Aspects of Energy: Classification of energy – Hydel, Thermal, Nuclear, Wind, & from Waste Products. Efficiency and effectiveness of energy utilization in Industry. Energy and energy analysis. Renewable and nonrenewable energy, Conventional and unconventional energy.

Module 3: Demand Side Management 7L
Energy Demand Management: Energy utilization, Instrumentation and data analysis, financial aspects of energy management, Energy management as a separate function and its place in plant management hierarchy. Energy Planning, Energy Staffing, Energy Organization, Energy Requirement. Energy Costing, Energy Budgeting, Energy Monitoring, Energy Consciousness, Energy Conversions, Energy Efficient Equipment, Energy Management Professionals, Environment Pollution due to Energy Use, Components of Pollution, Harmful Effects of Pollution, Measures taken to combat Pollution.

Module 4: Energy Audit and Energy Saving 7L
Energy Audit and analysis, Energy load measurements, System evaluation and simulation, Energy saving techniques and guidelines: Administrative control, Proper Measurement and monitoring system, Process control, proper planning & scheduling, increasing capacity utilization, improving equipment control, waste heat recovery, Change of energy source. Upgradation of Technology. Change of product specifications, Use of High efficiency equipment, Design modification for better efficiency, Improved periodic maintenance.

Module 5: Energy Control Centers 7L
Remote Telemetry; Remote Terminal Units; IEC TC 57 (870-5-1) Protocol Standard; Data Acquisition Procedure; Data Handling and Organization; Real Time Database; Alarm and Events; Disturbance Processing; Fault Locating Technology; Real Time Display; MIMIC Boards; Supervisory Remote Control; Load Dispatch Control Centers; Distribution Control Centers; Time

Keeping Systems.

Module 6: Integration of Distributed and Renewable Energy Systems to Power Grids 4L
DC-to-AC Converters; AC-to-AC Converters; DC-to-DC Converters; Plug-In Hybrid Electric Vehicles; Energy Storage Technologies; Microgrids.

Module 7: Legal Provisions 3L
The Prevention and Control of Pollution Act, 1974, The Energy Conservation Act, 2001, The Environmental Protection Act, 1986. The Electricity Act, 2003. National Electricity Policy. Rural Electrification.

Text Books:

1. Leon K. Kirchmayer, "Economic Operation of power system", Wiley India Pvt Ltd, July 2010.
2. Timothy J. E. Miller, "Reactive power control in electric systems", Wiley edition, August 2010
3. Albert Thumann, P.W, Plant Engineers and Managers Guide to Energy Conservation" TWI Press Inc, Terre Haute, 9th edition, 2008
4. Turner, Wayne C., "Energy Management Handbook", Lilburn, The Fairmont Press, 2001
5. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub,1998
6. Albert Thumann, "Handbook of Energy Audits", Fairmont Pr; 5th edition,1998
7. Howard E. Jordan, "Energy-Efficient Electric Motors and Their Applications", Plenum Pub Corp; 2nd edition 1994

Reference Books:

1. Jean-Claude Sabonnadi Are, "Low emission power generation technologies and energy management", John Wiley & Sons, August 2010
2. Ursula Eicker, "Low energy cooling for sustainable buildings", John Wiley & Sons, August 2010
3. Francois, Leveque, "Transport pricing of electricity networks", Springer 2003.
4. Giovanni Petrecca, "Industrial Energy Management: Principles and Applications", The Kluwer international series -207,1999 Springer 2000.
5. Parasiliti F., P. Bertoldi, "Energy Efficiency in motor driven systems", Springer, 2003.
6. Donald R. W., "Energy Efficiency Manual", Energy Institute Press,2000.
7. Petrecca, Giovanni, "Industrial Energy Management", Springer 1993.
8. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost-effective planning in Industrial facilities", IEEE Inc, USA.,1985.
9. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption.

Paper Name: Advanced Digital Signal Processing
Paper Code: PSM301C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Concept of Electrical Machines, Power System and Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Define different signals and systems and its discretization.
- **CO2.** Apply Fourier transform and Wavelet transforms to the real time signals.
- **CO3.** Illustrate various types of digital filters.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	3
CO2	3	2	2	3	2
CO3	3	2	2	3	3

Course Content

Module 1: Description of Signals and Systems **2L**
Types of signals and their characteristics, types of systems and their behavior.

Module 2: Discrete-time description of signals **4L**
Discrete-time sequences, their frequency domain behavior, comparison with analog signals, convolution of two sequences, sampling a continuous function to generate a sequence, reconstruction of continuous-time signals from discrete-time sequences.

Module 3: Discrete-time description of systems **4L**
Unit-sample response of a system, Time-invariant systems, Superposition principle for linear systems, Stability criterion for discrete-time systems, Causality criterion for discrete-time systems.

Module 4: Discrete-time Fourier transform **5L**
Definition of Fourier transform (FT), important properties of FT, properties of FT for real valued sequences, use of FT in signal processing, FT of special sequences, the inverse FT, FT of the product two discrete-time sequences.

Module 5: Discrete Fourier Transform **5L**
The definition of the Discrete Fourier Transform (DFT), efficient computation of DFT, properties of the DFT.

Module 6: Digital filter **5L**
Definition and anatomy of a digital filter, frequency domain description of signals and systems, replacing analog filters with digital filters, filter categories: IIR and FIR, recursive and non-recursive.

Module 7: Optimal and adaptive filters **3L**
Wiener filtering technique, adaptive filters and their applications.

Module 8: Spectrum estimation and analysis **4L**
Principles, Periodogram method, Blackman – Turkey method, fast correlation method. Autoregressive spectrum estimation.

Module 9: Wavelet Transforms **4L**

Fourier Transform and its limitations, Short Time Fourier Transform, introduction of Continuous Wavelet Transform, Discretization of the Continuous Wavelet Transform (DWT).

Text Books:

1. John G. Proakis, D.G. Manolakis and D.Sharma, “Digital Signal Processing Principles, Algorithms and Applications”, 4th edition, Pearson Education, 2012.
2. Sanjit K. Mitra, “Digital Signal Processing”, 4th edition, TMH, 2013.
3. P. Rameshbabu, “Digital Signal Processing”, Scitech Publications (India).
4. S.Salivahanan, A.Vallabraj & C. Gnanapriya, “Digital Signal Processing”, TMH Publishing Co.
5. A. Nagoor Kani, “Digital Signal Processing”, McGraw Hill.

Reference Books:

1. Oppenhiem V.A.V and Schaffer R.W, “Discrete – time Signal Processing”, 3rd edition, Pearson new international edition, 2014.
2. Sophocles J. Orfanidis, “Introduction to Signal Processing” 2nd edition, Prentice Hall, Inc, 2010.
3. Chi-Tsong Chen, “Digital Signal Processing; Spectral Computation and Filter Design”, Oxford University Press.

Paper Name: AI Techniques
Paper Code: PSM301D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Probability and Statistics.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Differentiate between various approaches to Artificial Intelligence.
- **CO2.** Design intelligent agents and distinguish between Utility based agents and Goal based agents.
- **CO3.** Apply concepts, methods, and theories of search, heuristics, games, knowledge representation, planning.
- **CO4.** Apply Natural language processing techniques.
- **CO5.** Understand the limitations of Artificial Intelligence techniques.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	2	2	1	2	3
CO3	3	2	2	3	-
CO4	2	2	3	-	3
CO5	3	2	2	3	2

Course Content

Module 1: Introduction **3L**
Introduction to Artificial Intelligence, various definitions of AI, AI Applications and Techniques, Turing Test and Reasoning - forward & backward chaining.

Module 2: Intelligent Agents **4L**
Introduction to Intelligent Agents, Rational Agent, their structure, reflex, model-based, goal-based, and utility-based agents, behavior and environment in which a particular agent operates.

Module 3: Problem Solving and Search Techniques **7L**
Problem Characteristics, Production Systems, Control Strategies, Breadth First Search, Depth First Search, iterative deepening, uniform cost search, Hill climbing and its Variations, simulated annealing, genetic algorithm search; Heuristics Search Techniques: Best First Search, A* algorithm, AO* algorithm, Minmax & game trees, refining minmax, Alpha – Beta pruning, Constraint Satisfaction Problem, Means-End Analysis.

Module 4: Knowledge Representation **6L**
Introduction to First Order Predicate Calculus, Resolution Principle, Unification, Semantic Nets, Conceptual Dependencies, semantic networks, Frames system, Production Rules, Conceptual Graphs, Ontologies.

Module 5: Planning **4L**
Basic representation for planning, symbolic-centralized vs. reactive distributed, partial order planning algorithm.

Module 6: Reasoning with Uncertain Knowledge **6L**
Different types of uncertainty - degree of belief and degree of truth, various probability constructs -

prior probability, conditional probability, probability axioms, probability distributions, and joint probability distributions, Bayes' rule, other approaches to modeling uncertainty such as Dempster-Shafer theory and fuzzy sets/logic.

Module 7: Understanding Natural Languages 6L

Components and steps of communication, contrast between formal and natural languages in the context of grammar, parsing, and semantics, Parsing Techniques, Context-Free and Transformational Grammars.

Text Books:

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 3rd edition, Pearson Education, 2015.
2. Elaine Rich and Kelvin Knight, Artificial Intelligence, 3rd edition, Tata McGraw Hill, 2017.
3. DAN.W. Patterson, Introduction to A.I. and Expert Systems – PHI, 2007.
4. Michael Wooldridge, An Introduction to MultiAgent Systems, 2nd edition, John Wiley & Sons, 2009.

Reference Books:

1. Fabio Luigi Bellifemine, Giovanni Caire, Dominic Greenwood, Developing Multi-Agent Systems with JADE, Wiley Series in Agent Technology, John Wiley & Sons, 2007.
2. W.F. Clocksin and C.S. Mellish, Programming in PROLOG, 5th edition, Springer, 2003.
3. Saroj Kaushik, Logic and Prolog Programming, New Age International Publisher, 2012.
4. Ivan Bratko, Prolog Programming for Artificial Intelligence, Addison-Wesley, Pearson Education, 4th edition, 2011.

Paper Name: Business Analytics
Paper Code: PSM302A
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Nil.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate basic concept / fundamentals of business statistics. Design intelligent agents and distinguish between Utility based agents and Goal based agents.
- **CO2.** Compute various measures of central tendency, Measures of Dispersion, Time Series Analysis, Index Number, Correlation and Regression analysis and their implication on Business performance.
- **CO3.** Evaluate basic concepts of probability and perform probability theoretical distributions.
- **CO4.** Apply Hypothesis Testing concepts and able to apply inferential statistics- t, F, Z Test and Chi Square Test.
- **CO5.** Perform practical application by taking managerial decision and evaluating the Concept of Business Analytics.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	-
CO2	3	2	-	2	3
CO3	-	2	2	-	3
CO4	3	2	-	3	3
CO5	3	2	2	3	2

Course Content

Module 1: Descriptive Statistics — 7L

Meaning, Scope, types, functions and limitations of statistics, Measures of Central tendency – Mean, Median, Mode, Quartiles, Measures of Dispersion – Range, Inter quartile range, Mean deviation, Standard deviation, Variance, Coefficient of Variation, Skewness and Kurtosis.

Module 2: Time Series & Index Number — 9L

Time series analysis: Concept, Additive and Multiplicative models, Components of time series, Trend analysis: Least Square method - Linear and Non- Linear equations, Applications in business decision-making.
Index Numbers: Meaning, Types of index numbers, uses of index numbers, Construction of Price.
Quantity and Volume indices: Fixed base and Chain base methods.

Module 3: Correlation & Regression Analysis — 7L

Correlation Analysis: Rank Method & Karl Pearson's Coefficient of Correlation and Properties of Correlation.
Regression Analysis: Fitting of a Regression Line and Interpretation of Results, Properties of Regression Coefficients and Relationship between Regression and Correlation.

Module 4: Probability Thoery & Distribution — 6L

Probability: Theory of Probability, Addition and Multiplication Law, Baye’s Theorem.
Probability Theoretical Distributions: Concept and application of Binomial; Poisson and Normal distributions.

Module 5: Hypothesis Testing & Business Analytics 7L

Hypothesis Testing: Null and Alternative Hypotheses; Type I and Type II errors

Testing of Hypothesis: Large Sample Tests, Small Sample test, (t, F, Z Test and Chi Square Test).

Concept of Business Analytics: Meaning types and application of Business Analytics, Use of Spread Sheet to analyze data – Descriptive analytics and Predictive analytics.

Text Books:

1. G C Beri – Business Statistics, 3rd ed, TATA McGraw Hill.
2. Chandrasekaran & Umaparvathi- Statistics for Managers, 1st edition, PHI Learning
3. Davis, Pecar – Business Statistics using Excel, Oxford
4. Ken Black – Business Statistics, 5th ed., Wiley India
5. Levin and Rubin – statistics for Management, 7th ed., Pearson

Reference Books:

1. Lind, Marchal, Wathen – Staistical techniques in business and economics, 13th ed, McGraw Hill.
2. Newbold, Carlson, Thorne – Statistics for Business and Economics, 6th ed., Pearson
3. S. C. Gupta – Fundamentals of Statistics, Himalaya Publishing
4. Walpole – Probability and Statistics for Scientists and Engineers, 8th ed., Pearson.

Paper Name: Industrial Safety
Paper Code: PSM302B
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Nil.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Explain various types of industrial safety measures as per factory act 1948.
- **CO2.** Apply required maintenance of industrial equipment.
- **CO3.** Prevent Wear and Corrosion of the equipment.
- **CO4.** Trace fault occurrence in the equipment.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	3	2	3	2	3
CO3	1	2	2	3	-
CO4	3	2	3	3	3

Course Content

Module 1: Industrial safety **7L**

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.

Module 2: Fundamentals of maintenance engineering **6L**

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.

Module 3: Wear and Corrosion and their prevention **7L**

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.

Module 4: Fault tracing **8L**

Fault tracing-concept and importance, decision tree concept, 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, vi. Electrical motors, Types of faults in machine tools and their general causes.

Module 5: Periodic and preventive maintenance **8L**

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.

Text Books:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

Reference Books:

1. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
2. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Paper Name: Operations Research
Paper Code: PSM302C
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Nil.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Apply the dynamic programming to solve problems of discreet and continuous variables.
- **CO2.** Apply the concept of non-linear programming
- **CO3.** Carry out sensitivity analysis
- **CO4.** Model the real world problem and simulate it.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	3	2	1	2	3
CO3	3	2	2	3	2
CO4	3	2	3	3	3

Course Content

Module 1: **7L**
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Module 2: **7L**
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

Module 3: **7L**
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem – max flow problem - CPM/PERT.

Module 4: **7L**
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Module 5: **8L**
Competitive Models, Single and Multi-Channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

Text Books:

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.

Reference Books:

1. Pannerselvam, Operations Research: Prentice Hall of India 2010.
2. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

Paper Name: Cost Management of Engineering Projects
Paper Code: PSM302D
Contact: 3L:0T:0P
Credit: 3

Prerequisites: Nil.

Course Outcomes: After the completion of the course, the student will be able to

- **CO1.** Demonstrate Cost Management Process.
- **CO2.** Explain different types of costing.
- **CO3.** Apply cost management to the engineering projects.

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	3	2	3	2	3
CO3	3	2	2	3	2

Course Content

Module 1: **3L**
Introduction and Overview of the Strategic Cost Management Process.

Module 2: **5L**
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.

Module 3: **11L**
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 nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Module 4: **12L**
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. 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.

Module 5: **5L**
Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Text Books:

1. Cost Accounting: A Managerial Emphasis, Prentice Hall of India, New Delhi

2. Charles T. Horngren and George Foster, Advanced Management Accounting

Reference Books:

1. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.
2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher.
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting.