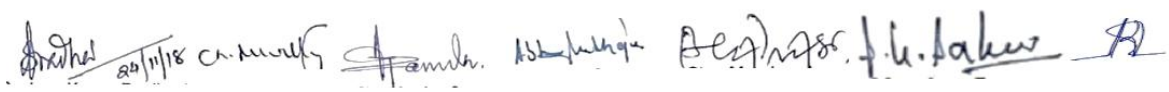
M. Tech.(PSE) Programme Structure

First Semester				
Sl. No	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	NP1PGCC01	Computational Methods And Techniques	3-1-0	4
2	NP1PGCC02	Internet Of Things	3-1-0	4
3	NP1EEBC03	**Branch Specialization Core - I** Power Conversion Devices And Drives	3-1-0	4
4	NP1EEBC04	**Branch Specialization Core - II** Advanced Power Systems	3-1-0	4
5	NP1EEBC05	**Branch Specialization Core - III** Smart Electrical Energy System	3-1-0	4
6	NP1CSBL01	Laboratory - I	0-0-4	4
7	NP1CSBL02	Report Writing & Seminar (Entrepreneurship & Start Up)	0-0-4	4
Total Credits				28



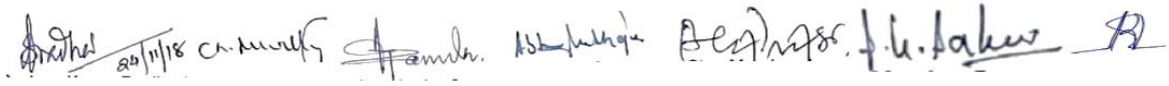
Second Semester				
Sl. No	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	NP2PRCC01	**Specialization Core – I** Electrical Power System Transient	3-1-0	4
2	NP2PRCC02	**Specialization Core – II** Power System Dynamics	3-1-0	4
3	NP2PRCC12	**Elective – I (Specialization Related)** 1.**Computer Aided Power System Protection** 2.HVDC Transmission & FACTS 3.EHVAC Transmission 4.Power System Reliability	3-1-0	4
4	NP2PECC10	**Elective – II (Departmental Related)** 1.**Power System Control & Instrumentation** 2.Advance Control System 3.Energy Generation From Waste 4.Power Quality Improvement Techniques	3-1-0	4
5	NP2PRCC12	**Elective – II (From Any Department)** 1. **Green Energy Resources & Technology** 2. Electric Drives In Hybrid Vehicle 3.Quantitative methods For Energy Management & planning 4.Advanced Numerical Methods	3-1-0	4
6	NP2ELBL01	Laboratory – II	0-0-4	4
7	NP2ELBL02	Design Project	0-0-4	4
Total Credits				28

***Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break.**

Third Semester				
Sl. No	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	NP3PGCC01	Research Methodology	3-1-0	4
2	NP3PGCC02	Intellectual Property Rights	3-1-0	4
3	NP3EEBL01	Pre Dissertation Work Evaluation		9
Total Credits				17

***Students going for Industrial Project/Thesis will complete these courses through MOOCs.**

Fourth Semester				
Sl. No.	**Course Code**	**Course Title**	**L-T-P**	**Credit**
1	NP4EEBL01	Dissertation Evaluation and Open Defence		17
Total Credits				17



First Semester

NP1EEBC03	Power Conversion Devices and Drives	(3-1-0)	4 Credits

Module-I (8Hrs)

Basic concepts of Modeling: Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine - voltage, current and Torque equations.

Dynamic Analysis of Synchronous Machine: Dynamic performance of synchronous machine, three-phase fault, comparison of actual and approximate transient torque characteristics.

Module- II (12Hrs)

Modeling of Synchronous Machine: Synchronous machine inductances –voltage equations in the rotor's dq0 reference frame- electromagnetic torque-current in terms of flux linkages-simulation of three phase synchronous machine- modeling of PM Synchronous motor

Poly-phase Induction Machines: Introduction, construction and principle of operation, Induction motor equivalent circuit, steady-state performance equations of the induction motor, steady-state performance, Measurement of motor parameters, Dynamic modeling of induction machines.

Module- III (12 Hrs)

Phase controlled rectifiers– Single phase half wave controlled rectifier with R, R-L, R-L with freewheeling diodes. Full wave controlled rectifier with various kind of loads. Half controlled and full controlled bridges with passive and active loads-Input line current harmonics and power factor-Inverter mode of operation. Three phase half wave controlled rectifier with R,R-L an R-L-E loads. Three phase semi and full converters with RL and RLE loads. Input side current harmonics and power factor. Dual converters-Circulating current mode and Non circulating current mode. AC voltage regulators and DC Choppers-Types of ac voltage regulators-single phase full wave ac voltage controllers-single phase transformer tap changers-Multistep transformer tap changer. Three phase ac voltage regulators. Output performance analysis of type A chopper, four quadrant chopper operation.

Module-IV (15 Hrs)

Introduction to motor drives: Components of power electronic Drives- Criteria for selection of Drive components-match between the motor and the load- Thermal consideration- match between the motor and the power electronics converter- characteristics of mechanical systems- stability criteria.

Induction motor drives: Torque speed characteristics of 3-phase induction motor drive, speed control of 3-phase induction motor by varying stator frequency and voltage – impact of non-sinusoidal excitation on induction motors- variable frequency converter classifications – variable frequency PWM-VSI drives- variable frequency square wave VSI drives- variable frequency CSI drives-comparison of variable frequency drives- Line frequency variable voltage drives- soft start of induction motors – speed control by static slip power recovery, static Cramer and Scherbius drives.

BOOKS RECOMMENDED:

1. The Generalized theory of electrical machines (Chapters: 1, 2, 3, 4, 5, 8 and 11 by B.Adkins and R.H. Hiiley.
2. Principle, Operation and Design of power Transformer By S.B Vasciitnsky.
3. The J & P transformer Book (Chapter: 22&23) By S. Austen Stigant and A.C Franklin.
4. Power System Stability & Control (Chapters: 8&9) By P.Kundur, McGraw Hill-1994.
5. Ned Mohan etial : Power Electronics , John wiley and sous
6. R.Krishnan: Electric Motor Drives – PHI publication
7. B K Bose: Modern Power Electronics and AC drives, Pearson Education (Asia)
8. P C Sen : Power Electronics TMH Publication
9. Dubey : Power Electronics Drives- Wiley Eastern

NP1EEBC04	Advanced Power Systems	(3-1-0)	4 Credits

Module- I (7 Hrs)
Modeling of Transmission lines & transformers with off-nominal taps. Power flow Analysis- NR and Fast decoupled methods Algorithm for short circuit studies, Z Bus Formulation, Unsymmetrical fault analysis using symmetrical components

Module- II(10 Hrs)
Optimal System Operation:
Generation allocation problem formulation, Loss Coefficients, Optimal load flow solution, Hydrothermal Coordination, Constraints in Unit- commitment, Unit commitment solution methods. Turbine & Generator-Load frequency Scheme, Steady state & dynamic analysis in frequency domain for single & two area system

Module-III(16 Hrs)
Power Quality Problems
Voltage Sag and over view of reliability: Characterization of voltage sag , definition, causes of voltage sag , voltage sag magnitude , monitoring, theoretical calculation of voltage sag magnitude , voltage sag calculation in non-radial systems, meshed systems, voltage sag duration. Reliability of power systems
PQ considerations in Industrial Power Systems: voltage sag effects, equipment behavior of power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC drives Adjustable speed DC drive and its operation, mitigation methods of DC drives.
Mitigation of Interruptions and Voltage Sags: Overview of mitigation methods- form fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface- voltage source converter, series voltage controller , shunt controller , combined shunt and series controller.

Module- IV (12 Hrs)
Power Pools & Electricity Markets: Inter-area transactions, multi-area power interchanges, Energy brokerage systems, Market design and auction mechanism, Pool versus bilateral markets and price formation, Role of Independent generators and system operator
Load characteristics and load forecast: Basic definitions- load definitions, load factor definitions, diversity principle in distribution systems, Load Forecast- factors affecting load forecasting methods, small areas load forecasting, spatial load forecasting methods, simulation, trending and mixed load forecasting methods

BOOKS RECOMMENDED:

1. Stagg G.W., Eabiad A.H. " Computer methods in Power system analysis." Mc Graw Hill, 1968.
2. Nagrath& Kothari, "Modern Power System Analysis"
3. Elaerd O.Z, " Electrical Energy System Theory- An Introduction"
4. "Understanding Power Quality Problems" by Math H J Bollen, IEEE Press.
5. Electrical power quality –R C Dugan, M.F,MGranghar, H.W.Beaty-TMH.
6. A. J. Wood and B. F. Wollenberg, Power generation, operation and control, Wiley-Interscience, 2nd Edition, 1996.
7. K. Bhattacharya, M. H. J. Bollen and J. E. Daalder, Operation of restructured power systems, Kluwer Academic Publishers, USA, 2001.

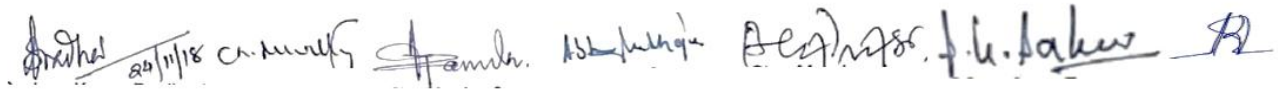
NP1EEBC05	Smart Electrical Energy System	(3-1-0)	4 Credits

Module- I (7 Hrs)
Non-renewable reserves and resources; renewable resources, Transformation of Energy. Solar Power: Solar processes and spectral composition of solar radiation; Radiation flux at the Earth's surface. Solar collectors. Types and performance characteristics. Applications.
Solar Thermal System: Solar Collection Devices; their analysis; Solar Collector Characteristics; Solar Pond; application of solar energy to space heating etc.

Module- II (8 Hrs)
Wind Energy: Wind energy conversion; efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power - speed and torque - speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self -excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation

Module- III (15 Hrs)
Distributed Generation: Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources, Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection Distribution system performance and operation Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems

Module- IV (15 Hrs)
Introduction to smart grid: Introduction to the smart grid, including objectives and functions, views of the smart grid with in the industry, and design criteria.
BOOKS RECOMMENDED :
1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems: Oxford Univ. Press, 2005.
2. S.A. Abbasi, N. Abbasi, Renewable Energy Sources and Their Environmental Impact: Prentice Hall of India, 2004.
3. S.P. Sukhatme - Solar Energy: Principles of thermal Collection and Storage,TMH,New Delhi
4. H.P. Garg and Jai Prakash - Solar Energy: Fundamentals and Applications,TMH
5. Ned Mohan et. al : Power Electronics ,John Wiley and Sons
6. 6.P C Sen : Power Electronics , TMH
7. G K Dubey et. al :Thyristorised Power Controllers , Wiley Eastern Ltd.
8. B K Bose : Modern Power Electronics and AC Drives, Pearson Edn (Asia)



NP1PGCC01	Computational Methods And Techniques	(3-1-0)	4 Credits

MODULE-I:

Neural Networks: Artificial Neural Network and Introduction, Learning Rules, Knowledge Representation and Acquisition, Different Methods of Learning.

Algorithms of Neural Network: Feed-forward Error Back Propagation, Hopfield Model, Kohonen'sFeatrure Map, K-Means Clustering, ART Networks, RBFN, Application of Neural Network to the relevant field.

MODULE-II:

Fuzzy Logic: Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables,Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy System Design, FKBC and PID Control, Antilock Breaking System(ABS), Industrial Applications.

MODULE-III:

Optimization Fundamentals: Definition, Classification of Optimization Problems, Unconstrained and Constrained Optimization, Optimality Conditions.

Linear Programming: Simplex Method, Duality, Sensitivity Methods

Non-Linear Programming: Newton's Method, GRG Method, Penalty Function Method, Augmented Langrange Multiplier Method, Dynamic Programming and Integer Programming, Interior Point Methods, Karmakar's Algorithm, Dual Affine, Primal Affine.

MODULE-IV:

Genetic Algorithm: GA and Genetic Engineering, Finite Element based Optimization, PSO,BFO, Hybridization of Optimization Technique, Application of Optimization Technique for Solving Projects(Project solutions). Implementation of Branch Relevant Industrial Applications by Matlab Code.

Books Recommended:

1. Neural Networks- by Simon Haykin
2. Fuzzy Logic with Engineering Application- by ROSS J.T (Tata Mc)
3. Neural Networks and Fuzzy Logic – by Bart Kosko
4. An introduction Fuzzy Control – by D.Driankor, H. Hellendorn, M.Reinfrank (Narosa Pub)
5. Fuzzy Neural Control – by Junhong NIE & Derek Linkers (PHI)
6. Related IEEE/IEE Publications
7. Fuzzy System Design Principles, Building Fuzzy IF-THEN Rule Bases – by Riza C. Berikiu and Trubatch, IEEE Press
8. Ashok D. Begundu&chandrapatla T.R "Optimization concept and application in engineering",Prentice Hall,1999
9. Rao S.S "Engineering Optimization"
10. Gill,Murray and Wright ,"Practical Optimization"
11. James A.Memoh. "Electric Power System Application Of Optimization".
12. Song Y.,"Modern Optimization Techniques In Power System"
13. Optimization Research;PrabhakarPai,Oxford University Press.

NP1PGCC02	Internet Of Things	(3-1-0)	4 Credits

MODULE I

Introduction to Internet of Things

Introduction-Definition & Characteristics of IoT , **Physical Design of IoT**- Things in IoT , IoT Protocols, **Logical Design of IoT**- IoT Functional Blocks, IoT Communication Models, IoT Communication APIs , **IoT Enabling Technologies**- Wireless Sensor Networks , Cloud Computing, Big Data Analytics , Communication Protocols , Embedded Systems, **IoT Levels & Deployment Templates.**

MODULE II

Domain Specific IoTs

Home Automation: Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detectors, Cities-Smart Parking, Smart Lighting, Smart Roads, Structural Health Monitoring, Surveillance, Emergency Response,

Environment-Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection, River Floods Detection , **Energy**- Smart Grids , Renewable Energy Systems , Prognostics , **Retail**-Inventory Management , Smart Payments , Smart Vending Machines , **Logistics**-Route Generation & Scheduling , Fleet Tracking , Shipment Monitoring , Remote Vehicle Diagnostics, **Agriculture**-Smart Irrigation ,Green House Control ,**Industry** -Machine Diagnosis & Prognosis Indoor Air Quality Monitoring , **Health & Lifestyle –**Health & Fitness Monitoring, Wearable Electronics **IoT and M2M Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT**-Software Defined Networking , Network Function Virtualization

MODULE III

IoT Platforms Design Methodology

IoT Design Methodology-Purpose & Requirements Specification ,Process Specification, Domain Model Specification, Information Model Specification , Service Specifications , IoT Level Specification, Functional View Specification , Operational View Specification , Device & Component Integration , Application Development, **Case Study on IoT System for Weather Monitoring, Motivation for Using Python IoT Physical Devices & Endpoints What is an IoT Device**-Basic building blocks of an IoT Device, **Exemplary Device: Raspberry Pi**, **About the Board, Linux on Raspberry Pi , Raspberry Pi Interfaces –** Serial, SPI , I2C , **Programming Raspberry Pi with Python**-Controlling LED with Raspberry Pi , Interfacing an LED and Switch with Raspberry Pi ,Interfacing a Light Sensor (LDR) with Raspberry Pi , **Other IoT Devices**-pcDuino, Beagle Bone Black , Cubieboard

MODULE IV

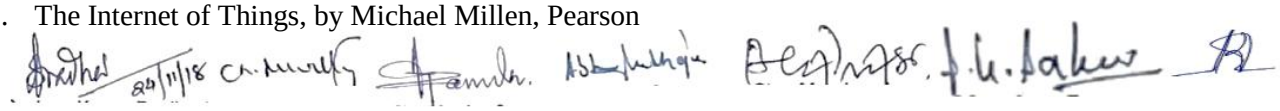
IoT&Beyond : Use of Big Data and Visualization in IoT, Industry 4.0 Concepts. Overview of RFID, Low-power design (Bluetooth Low Energy), range extension techniques (data mining and mesh networking), and dataintensive IoT for continuous recognition applications. Overview of Android / IOS App Development tools & Internet of Everything

Text Books:

1. Internet of Things, A Hands on Approach, by Arshdeep Bahga & Vijay audisetti, University Press.

Reference Books:

1. The Internet of Things, by Michael Millen, Pearson



NP1CSBL01	**Laboratory - I**	**(0-0-4)**	**4 Credits**

The concerned instructor will define the experiment list in sync with the theory subject.

NP1CSBL02	**Report Writing & Seminar (Entrepreneurship & Start Up)**	**(0-0-4)**	**4 Credits**

Second Semester

NP2PRCC01	Electrical Power System Transient	(3-1-0)	4 Credits

Module-I (11 Hours)
INTRODUCTION TO FAST TRANSIENTS:
Origin and nature of power system Transients, traveling waves on transmission system, the line equation, the shape attenuation and distortion of waves, reflection of traveling waves, successive reflections, traveling waves on multi conductor systems, transition points on multi conductor circuits.

Module-II (10 Hours)
LIGHTNING: Charge formation , mechanism of lightning stroke. Mathematical model of lightning stroke.
THEORY OF GROUNDS WIRES : Direct stoke to a tower, effect of reflection up and down the tower , the counterpoise.

Module-III (10Hours)
SWITCHING SURGES:
Normal frequency effects, high charging currents, cancellation waves, recovery voltage, restricting phenomena. Protection of transmission systems against surge.
HIGH FREQUENCY OSCILLATIONS AND TERMINAL TRANSIENTS OF TRANSFORMER

Module-IV (12 Hours)
INSULATION
COORDINATION:
Insulation coordination procedures (IEC) for high voltage systems: Design criteria, classification of overvoltages, insulation design for switching, lightning and temporary overvoltages, pollution, application of arresters for protection of lines and stations, statistical methods of insulation coordination, risk of failure, test prescriptions. Insulation coordination procedures (IEC) for low voltage systems: representative overvoltages, selection of clearance and creepage distances, macro and micro environments, testing techniques, transient (switching and lightning) voltage surge suppression in industrial and commercial electrical installations, protection of electronic devices.

TEXT BOOKS

1. Allan Greenwood , Electrical Transients in power Systems , Wiley Iterscience, 1991 2.
2. Lou Van Der Sluis, Transients in power Systems , John Wiley & Sons Ltd, 2001
3. RRudenterg, Transient Performance of Electric power systems, Phenomenon in Lumped Networks, MGH, 1950
4. RRudenterg, Electric Stroke waves in power systems, Harvard University press, Cambridge, Massachusetts, 1968
5. Transmission Line Reference Book, EPRI, USA, 1982-11

NP2PRCC02	Power System Dynamics	3-1-0	4 Credits

Module-I (15 Hours)

Power System Stability Problems: Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.

Small Signal Stability: State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, small signal stability of a single machine infinite bus system,

Module-II (15 Hours)

Studies of parametric effect: effect of loading, effect of K , effect of type of load, Hopf bifurcation, Electromechanical oscillating modes, Stability improvement by power system stabilizers. Design of power system stabilizers.

Large Perturbation Stability: Transient stability: Time domain simulations and direct stability analysis techniques (extended equal area criterion)

Module-III (15 Hours)

Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modeling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multi-machine PEBS.

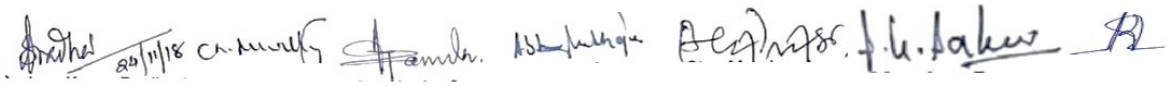
Module IV(15 Hours)

Sub Synchronous Oscillations: Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters, Sub Synchronous Resonance (SSR): characteristics of series capacitor – compensated transmission systems, self – excitation due to induction generator effect, torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems.

Voltage stability, System oscillations

Text Books:

1. Prabha. Kundur, Power system stability and control, Tata McGraw-Hill, 1994
2. P. Sauer and M. Pai, Power system dynamics and stability, Prentice Hall, 1998. 12



NP2PRCC12	Computer Aided Power System Protection	3-1-0	4 Credits

Module-I (12 Hours)

Introduction To Computer Relaying: Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Analog to digital converter, Anti-aliasing filter, Substation computer hierarchy.

Relaying Practices: Introduction to protection systems, Functions of a protection system, Protection of transmission lines, Transformer, reactor & generator protection, Bus protection, Performance of current & voltage transformers.

Module-II (11 Hours)

Mathematical Basis For Protective Relaying Algorithms: Introduction, Fourier series, Other orthogonal expansion, Fourier transform, Use of fourier transform, Discrete fourier transform, Introduction to probability & random processes, Random processes, Kalman filtering.

Transmission Line Relaying: Introduction, Sources of error, relaying as parameter estimation, Beyond parameter estimation, Symmetrical component distance relay, protection of series compensated lines.

Module-III (10 Hours)

Protection Of Transformers, Machines & Buses: Introduction, Power transformer algorithms, Generator protection,, Motor protection, Digital bus protection.

Hardware Organization In Integrated Systems: The nature of hardware issues, Computers for relaying, the substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary equipment, Redundancy & backup, Servicing, training & maintenance.

Module-IV (11 Hours)

System Relaying & Control: Introduction, Measurement of frequency & phase, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurement in dynamic state estimation, Monitoring.

Developments In New Relaying Principles: Introduction, Traveling waves on single-phase lines, Traveling waves on three-phase lines, Traveling waves due to faults, Directional wave relays, Traveling wave distance relay, Differential relaying with phasors, Traveling ` wave differential relays, Adaptive relaying,

Text Book:

1. A.G. Phadke and J.S. Thorp, " Computer Relaying for Power Systems", John Wiley and Sons, 1994 21

	HVDC Transmission & FACTS	3-1-0	4 Credits

Module-I: (10hours)

Introduction: Comparison of AC-DC Transmission, Description and application of HVDC transmission, DC System components and their functions

Analysis of HVDC Converters: Pulse number, Converter configuration, Analysis of Graetz circuit, Bridge characteristics, 12 pulse converter.

Module-II : (11hours)

HVDC Control: Principles of DC Link control-Converter control characteristics- System control, Firing angle control- Current and extinction angle control, DC link power control, Reactive power control and VAR sources, MTDC system- types- control and protection- DC circuit breakers

Module-III: (15hours)

FACTS Concept and General System:

Transmission interconnections, Flow of power in AC system, Power flow and dynamic stability considerations of a transmission interconnection, Relative importance of controllable parameters, Basic types of FACTS controllers, Benefits from FACTS Technology, In-perspective: HVDC or FACTS

Module-IV: (15hours)

Compensators: Objective of series and shunt compensation, SVC and STATCOM, GCSC, TSSC, TCSC, and SSSC, UPFC, IPFC, Generalized and Multifunctional FACTS Controllers

Text/References:

1. Padiyar K.R., “HVDC Power Transmission System”, Wiely Eastern PVT Limited
2. Kimbark, “Direct Current transmission”, Vol.1, John Wielly, New York, 1971
3. Understanding FACTS: Cocepts and Technology of Flexible AC Transmission Systems. By N. G. Hingorani and L. Gyugi, Standard Publisher Distributors, IEEE Press, Delhi
4. Flexible AC Transmission Systems. By J. Arillage 13

	EHVAC Transmission	3-1-0	4 Credits

Module- I (10 hrs)

Introduction to EHV Transmission Comparison of AC and DC Transmission Systems.Parameters of EHV Lines:- Resistance of conductors, bundle conductors, Inductance of EHV Line configurations line capacitance, Sequence Inductance and capacitance, Line parameters for modes of propagation, resistance and Inductance of Ground returns.

Module- II (10 hrs)

Voltage Gradient of conductors:- Field of sphere gap, field of line charges and their properties. Charge – potential relations for multi-conductor lines surface voltage gradient and conductors without and with ground wires consideration, gradient factors, Distribution of voltage gradient on sub-conductors of bundle.

Module- III (10 hrs)

Corona effects- I :Power loss and Audible Noise Corona loss, Charge- Voltage diagram. Attenuation of traveling waves Audible.

Noise: Generation, Characteristics and its limitation, Measurement, meters, 1-phase and 3-phase AN levels, Day-Night equivalent Noise level.

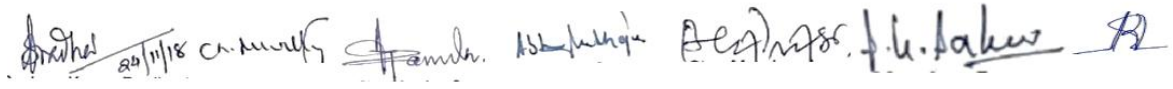
Power frequency voltage control and over-voltage:- Generalized constants, Cascade connection of components-shunt and series compensation. Sub-synchronous Resonance in series- capacitor compensated lines, Static Reactive compensating systems.

Module – IV (10 hrs)

Over voltage in EHV systems caused by switching operations:- Origin of over voltage and their types, short circuit current and circuit breaker. Recovery voltage and the circuit breaker, Over voltage caused by interruption of inductive current, Interruption of capacitive currents, Ferro resonance over voltage, calculation of switching surges single phase equivalents, distributed parameter line energized by source, generalized equations for single phase representation, Generalized equation of three phase systems, inverse Fourier transform for the general case, Reduction of switching surges on EHV systems, Experimental and calculated results of switching surge studies.

Text Books:-

1. Begamudre R.D., “Extra High Voltage A.C. Transmission” McGraw Hill 1968.



	Power System Reliability	3-1-0	4 Credits

Module-I (10Hours)

Generating Capacity Basic Probability Methods:

The generation system model, Loss of load indices, Equivalent forced outage rate, Capacity expansion analysis, Scheduled outages, Evaluation methods on period basis, Load forecast uncertainty, Forced outage rate uncertainty, Loss of energy indices.

Generating Capacity Frequency & Duration Method: The generation model, System risk indices.

Module-II (12 Hours)

Interconnected Systems: Probability error method in two interconnected systems, Equivalent assisting unit approach to two interconnected systems, Factors affecting the emergency assistance available through the interconnections, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected system, multi connected system, Frequency & duration approach.

Operating Reserve: General concepts, PJM method, Extension to PJM method, Modified PJM method, Postponable outages, Security function approach, Response risk, Interconnected systems.

Module-III (10 Hours)

Composite Generation & Transmission Systems: Radial configurations, Conditional probability approach, Network configurations, State selection, System & load point indices, Application to practical systems, Data requirements for composite system reliability.

Plant & Station Availability: Generating plant availability, Derated states & auxiliary systems, Allocation & effect of spares, Protection systems, HVDC systems.

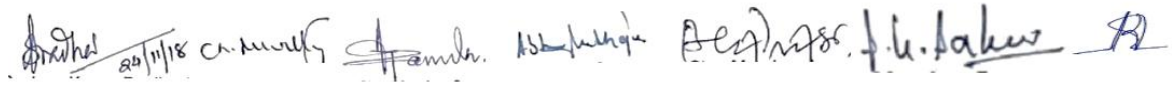
Module-IV (11 Hours)

Distribution Systems Basic Techniques & Radial Networks: Evaluation techniques, additional interruption indices, Application to radial systems, effect of lateral distributor protection, Effect of disconnects, Effect of protection failures, effect of transferring loads, Probability distributions of reliability indices.

Distribution Systems-Parallel & Meshed Networks: Basic evaluation techniques, Inclusion of busbar failures, Inclusion of scheduled maintenance, Temporary & transient failures, Inclusion of weather effects, Common modes failures, Common mode failures & weather effects, Inclusion of breaker failures.

Text Books :

1. Billinton Roy& Allan Ronald “Reliability of Power system”, Pitman Pub. 1984 2.Richard Elect. Brown, “Electric Power Distribution Reliabilty”, CRC Press



NP2PECC10	Power System Control & Instrumentation	3-1-0	4 Credits

Module-1

Control of voltage, frequency and tie-line power flows, Q-V and P-f control loops. Mechanism of real and reactive power control.

Module-2

Net interchange tie line bias control. Optimal, sub-optimal and decentralized controllers.AGC in isolated and interconnected power systems, AGC with economic dispatch.Discrete mode AGC.

Module-3

Time error and inadvetent interchange correction techniques. On line computer control.Distributed digital control.Data acquisition systems.Emergency control, Preventive control, system wide optimization.

Module-4

SCADA.supervisory control, supervisory master stations, remote terminal units, communication links, SCADA systems applications in power networks. System measurements using SCADA and computer Control.

Text Books /References:

1. Wood A. J. and Wollenberg B.F., " Power Generation, Operation and Control, John Wiley & Sons
2. Kundur P. and Balu N. J., "Power System Stability and Control", EPRI Series, McGraw-Hill International Book Company.
3. "Modern Power Station Practice, Volume F: Control and Instrumentation", British Electricity
4. International, Peragmon Press.
5. Cegrell T., "Power System Control Technology", Prentice Hall International Edition.
6. Grainger J. J. and Stevenson W. D., "Power System Analysis", Tata McGraw-Hill Publishing Company Limited.
7. Anderson P. M. and Fouad A. A., "Power system control and stability", IEEE Press.
8. Ronald L. Krutz"Securing SCADA system"johnwilly publication.
9. Fabiosaccomanno"Electric Power System Analysis and Control"IEEE Press
10. AtifS. Debs,"Modern power systems control and operation",Kluwer academic publishers

	Advance Control System	3-1-0	4 Credits

Module-I : (10 Hours)

Digital Control: State Space Representations of Discrete Time Systems, Solution of Discrete Time State Equations, Discretization of Continuous Time State Equations. Controllability and observability of Linear Time Invariant Discrete Data Systems, Pole Placement, Deadbeat response, Digital Simulation.

Module -II : (12 Hours)

Optimal Control: Performance Indices, Quadratic Optimal Regulator / Control Problems, Formulation of Algebraic Riccati Equation (ARE) for continuous and discrete time systems. Solution of Quadratic Optimal Control Problem using Lagrange Multiplies for continuous and discrete-time systems. Evaluation of the minimum performance Index, Optimal Observer, The Linear Quadratic Gaussian (LQG) Problem, Introduction to H control

Module - III : (11 Hours

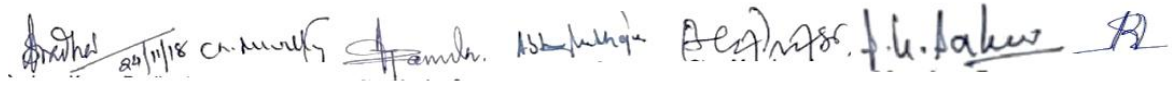
Nonlinear Systems: The Aizerman and Kalman Conjectures : Popov's stability criterion, the generalized circle criteria, simplified circle criteria. Simple variable structure systems, sliding mode control, feedback linearization, Model reference adaptive control, (MRAC), Self Tuning Regulator (STR).

Module - IV : (10 Hours)

Fuzzy Logic Control : Fuzzy sets and crispsets, Fuzzy Relations and composition of Fuzzy Relations, Introduction to Fuzzy Logic Controllers.

Text/References:

1. Discrete Time Control Systems, by K.Ogata, 2nd edition (2001), Pearson Education publication.
2. Digital Control Systems, by B.C. Kuo, 2nd edition (1992), Oxford University Press.
3. Digital Control and State Variable Methods, by M.Gopal, 3rd edition (2009), Tata Mc. Graw Hill Education Pvt. Ltd.
4. Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).
5. Design of Feedback Control Systems by Raymond T. Stefani, B.Shalia, Clement J. Savant, Jr. Gen H. Hostetter, 4th edition (2002), Oxford University Press.
6. Introduction to Control Engineering (Modeling, Analysis and Design) by Ajit K. Mandal, New Age International (P), Ltd., Publishers (2006).
7. Non Linear Systems, by Hassan K. Khallil, 3rd edition (2002), Prentice Hall, Inc. (Pearson Education), Publications.
8. Control Theory (Multivariable and nonlinear Methods) by Torkel Glad &LennartLjung, Taylor & Francis (2009).



	Energy Generation From Waste	3-1-0	4 Credits

MODULE-I:
Solid Waste Sources Solid Waste Sources, types, composition, Properties, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste.

MODULE-II:
Status of technologies for generation of Energy from Waste Waste Treatment and Disposal Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration.

MODULE-III:
Land Fill method of Solid waste disposal Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leachate and gases, Environmental monitoring system for land fill gases.

MODULE-IV:
Energy Generation from Waste Bio-chemical Conversion: Sources of energy generation, Anaerobic digestion of sewage and municipal wastes, Direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion: Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers , Briquetting, Utilization and advantages of briquetting, Environmental benefits of Bio- chemical and Thermo- chemical conversion .

Text Books/References:

1. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies.An Imprint of Elsevier, New Delhi (2003).
2. P. AarneVesilind, William A. Worrell and Debra R. Reinhart.Solid Waste Engineering. Thomson Asia Pte Ltd. Singapore (2002)
3. M. Dutta , B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
4. AmalenduBagchi. Design, construction and Monitoring of Landfills.John Wiley and Sons. New York. (1994)
5. M. L. Davis and D. A. Cornwell.Introduction to environmental engineering.McGraw Hill International Edition, Singapore (2008)
6. C. S. Rao. Environmental Pollution Control Engineering.Wiley Eastern Ltd. New Delhi (1995)
7. S. K. Agarwal. Industrial Environment Assessment and Strategy. APH Publishing Corporation. New Delhi (!996)
8. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), “Biomass Conversion Processes for Energy and Fuels”, New York, Plenum Press, 1981
9. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., “Solid Waste Management”, New

York, Van Nostrand, 1973
10. George Tchobanoglous, Hilary Theisen and Samuel Vigil Prsl: Tchobanoglous, George Theisen,Hillary Vigil, Samuel, “Integrated Solid Waste management: Engineering Principles and Management issues”, New York, McGraw Hill, 1993
11. C Parker and T Roberts (Ed), Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
12. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, 2000
13. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
14. G Rich et.al, Hazardous Waste Management Technology, Podvan Publishers, 1987
15. AD Bhide, BB Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983

	Power Quality Improvement Techniques	3-1-0	4 Credits

Module-I : (15 Hours)

Concept of Power Quality:

Frequency variations, voltage variations- sag and swell, waveform distortion –dc offset, harmonics, inter-harmonics, notching and noise. Fundamentals of Harmonics: Representation of harmonics, waveform, and harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, and NORSOK.

Causes of Harmonics:

2-pulse, 6-pulse and 12-pulse converter configurations, input current waveforms and their harmonic spectrum; Input supply harmonics of AC regulator, integral cycle control, cyclo-converter, transformer, rotating machines, ARC furnace, TV and battery charger.

Module-II: (14 Hours)

Effect of Harmonics: Parallel and series resonance, effect of harmonics on static power plant – transmission lines, transformers, capacitor banks, rotating machines, harmonic interference with ripple control systems, power system protection, consumer equipments and communication systems, power measurement. Elimination/ Suppression of Harmonics: High power factor converter, multi-pulse converters using transformer connections(delta, polygon).

Passive Filters: Types of passive filters, single tuned and high pass filters, filter design criteria, double tuned filters, damped filters and their design. Active Power Filters: Compensation principle, classification of active filters by objective, system configuration, power circuit and Control strategy.

Module-III : (15 Hours)

PWM Inverter: Voltage sourced active filter, current sourced active filter, constant frequency control, constant tolerance band control, variable tolerance band control. Shunt Active Filter: Single- phase active filter, principle of operation, expression for compensating current, concept of constant capacitor voltage control; Three-phase active filter: Operation, analysis and modeling; Instantaneous reactive power theory. Three-phase Series Active Filter: Principle of operation, analysis and modeling. Other Techniques: Unified power quality conditioner, voltage source and current source configurations, principle of operation for sag, swell and flicker control.

Text/References:

1. Derek A. P., “Power Electronic Converter Harmonics”, IEEE Press. 1989
2. Arrillaga J., Smith B. C., Watson N. R. and Wood A. R., “Power System Harmonic Analysis”, 2nd2008Ed., Wiley India.
3. Arthur R. B., “Power System Analysis”, 2nd Ed., Pearson Education. 2008
4. Arrillaga J., Braedlley D. A. and Bodger P. S., “Power System Harmonics”, John Wiley and
5. Sons.1985
6. Dugan R. C., McGranaghan M. F. and Beaty H. W., Electrical Power System Quality”, McGraw-Hill International Book Company.1996
7. Sankaran C., “Power Quality”, CRC Press. 2001

NP2PRCC12	Green Energy Resources & Technology	3-1-0	4 Credits

Module-I :

Solar photovoltaic:

Introduction, Solar cell characteristics, Losses in solar cells, Modeling of solar cell, Solar PV modules, Bypass diode in PV module, Design of PV module, PV module power output, I- V curve of PV module, BOS of PV module, Batteries for solar PV, Battery charge controllers, DC-DC converters, DC-AC converters, MPPT, Different algorithm for MPPT, Types of PV system, Performance analysis of solar cell, Working of solar cell power plant.

Module-II:

Wind energy:

Wind energy conversion, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self-excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation;

Ocean Energy:

Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems- ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.

Module-III :

Biomass Energy:

Introduction, Biomass conversion technology, Biogas, Composition of Biogas, Properties of Biogas, Biogas production reaction, Factor affecting biogas production, Biogas plant site selection, Biogas plants, Types of Biogas plants, Biogas purification, Biogas storage, Biogas dispensing, Advantages and disadvantages of Biogas, Emission from Biogas engines, Digester Filling and Biogas plant operation, Biogas digester sizing.

Module-IV :

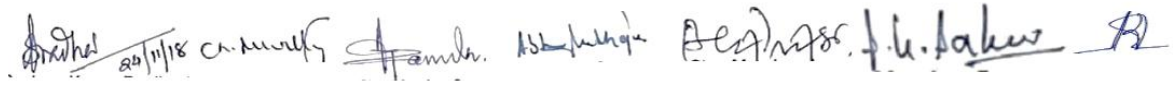
Hybrid Power System: Introduction, Need for hybrid systems, Range of hybrid systems, Types of Hybrid systems, Diesel-PV system, Wind-PV system, Micro Hyde-PV system, Biomass-PV system, Electric vehicles, Hybrid electric vehicles.

Energy Conservation, Management and Economics: Impact of renewable energy on environment, Principle and strategies of energy conservation, energy management, energy audit, energy planning, total energy system concept, Power tariff, Cost of electricity production from renewable.

Text/Reference Books:

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems: Oxford Univ. Press, 2005.
2. S. S. Thipse, Non-Conventional and Renewable Energy Sources, Narosa Publishing House, 2014.
3. S.A. Abbasi, N. Abbasi, Renewable Energy Sources and Their Environmental Impact: Prentice Hall of India, 2004.
4. S.P. Sukhatme - Solar Energy: Principles of thermal Collection and Storage,TMH,New

Delhi
5. Duffic and Beckman - Solar Engineering of Thermal Processes, John wiley
6. Green Management and Green Technologies: Exploring the Causal Relationship by Jazmin Seijas Nogarida,2008.
7. Green Marketing and Management: A global Perspective by John F. Whaik, 2005



	Electric Drives In Hybrid Vehicle	3-1-0	4 Credits

Module-I: (11 Hours)

Introduction: History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs. Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell Vehicles and its constituents.

Module-II: (10 Hours)

Plug-in Hybrid Electric Vehicle: PHEVs and EREVs, blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.

Module-III: (10 Hours)

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Module-IV: (11 Hours)

Electric Machines and Drives in HEVs: Induction motor drives, Field oriented control of induction machines; Permanent magnet motor drives; Switched reluctance motors; Doubly salient permanent magnet machines.

Text Books/References:

1. Pistooa G., "Power Sources , Models, Sustainability, Infrastructure and the market", Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., " Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives"1995

	Quantitative methods For Energy Management & planning	3-1-0	4 Credits

Module-I:
A review of probability concepts, Forecasting and decision making in view of multi-variant techniques, Linear programming, Graphical solution, Simplex method, Duality and post-optimality analysis, Integer programming .

Module-II:
Optimal technology mix in micro and macro level energy planning exercises, Sequencing, Queuing theory, Networks, PERT and CPM,

Module-III:
Decision theory, Markov analysis, Nonlinear programming, Decision making with uncertainty, decision making with multiple objectives, Deterministic and probabilistic dynamic programming, Regression analysis.

Text/References

1. Operations Research, An Introduction, Sixth Edition, 2000, by HA Taha, Prentice-Hall of India Pvt. Ltd.
2. Quantitative Techniques in Management, First Edition, 1997, by ND Vohra, Tata McGraw-Hill Publishing Company Ltd, New Delhi.

	Advanced Numerical Methods	3-1-0	4 Credits

Module I:
Introduction to digital computers & Programming - an overview; Errors polynomial approximations and interpolations - Numerical differentiation & Integration.

Module II:
Evaluation of single and multiple integrals, Newton's method, variation and weighted residual methods. Matrices – Linear equations, Eigenvalues and Eigenvectors nonlinear equations.

Module III:
Harmonic and bi-harmonic equations - solutions, convergence, completeness & stability.

Module IV:
Initial and boundary value problems of finite difference method, Implicit & Explicit scheme.

References

1. Jain M.K, SRK Iyenge and RK Jain."Numerical Methods for Scientific &Engg.Computation".
2. Mathews J. H "Numerical Methods for Mathematics, Science and Engineering".
3. Gerld C.F and PO Wheatley "Applied Numerical Analysis".
4. Gupta S.C and V. K. Kapoor "Fundamentals of Applied Statistic", Sultan Chand & Sons.
5. Johnson R.A " Probability and Statistics for Mngineers.
6. Rajeshwaran S, "Numerical Methods in Science & Engineering (A Practical Approach)" , Willey Publication.

NP2ELBL01	Laboratory - II	(0-0-4)	4 Credits

The concerned instructor will define the experiment list in sync with the theory subject.

NP2ELBL02	Design Project	(0-0-4)	4 Credits

Third Semester

NP3PGCC01	Research Methodology	(3-1-0)	4 Credits

Module I:
Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

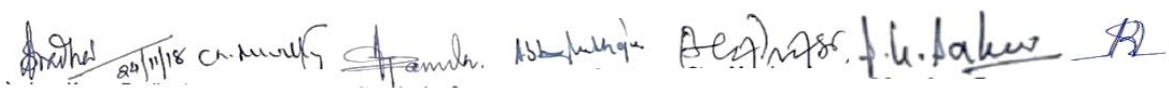
Module II:
Measurement and Data Collection. Primary data, Secondary data, Design of questionnaire ; Sampling fundamentals and sample designs. Measurement and Scaling Techniques, Data Processing.

Module III:
Data Analysis – I: Hypothesis testing; Z-test, t-test, F-test, Chi-square test. Analysis of variance. Non-parametric Test – Sign Test, Run test, Krushall – Wallis test

Module IV:
Data Analysis – II: Factor analysis, Multiple Regressions Analysis. Discriminant Analysis, Use of SPS Package.

Reference Books

1. Research Methodology, Chawla and Sondhi, Vikas
2. Research Methodology, Paneersevam, PHI



NP3PGCC01	Intellectual Property Rights	3-1-0	4 Credits

Unit 1 - Introduction
Intellectual property: meaning, nature and significance, need for intellectual property Right (IPR), IPR in India – Genesis and development, IPR in abroad, Examples:-Biotechnology Research and Intellectual Property Rights Management.
What is a patent, What can be protected by a patent, Why should I apply for a patent? Patent Law, Patentability requirements, Non-Patentable subject matters, Layout of the Patents. Procedure for domestic and international filing of applications, Restoration, Surrender and Revocations of Patents, Rights of Patentee and Working of Patent, Licensing and Enforcing Intellectual Property.

Unit 2 – Copyrights
Copyright: meaning, scope; What is covered by copyright? How long does copyright last? Why protect copyright? Related rights, Rights covered by copyright. Ownership: Duration, Division, Transfer and Termination of Transfers.

Unit 3 – Infringement and Remedies
Literal and non-literal infringement, Role of claims, Doctrines on infringement: Equivalent doctrine, Pith and Marrow doctrine, Comparative test. Defenses: Gillette Defense, General grounds, Patents granted with conditions, Parallel import. Remedies: Civil, Administrative.

Unit 4 – State Law: Trade Secret, Contract, Misappropriation, Right of Publicity
Trademarks, Trade Secret - Overview, Requirements, Misappropriation of Trade Secret, Departing Employees, Remedies, Criminal Liability, Misappropriation, Clickwrap Agreements, Idea Submissions; Right of Publicity, Federal Preemption, Review.

Books:-

1. W. R. Cornish and D. Llewellyn, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Rights, Sweet & Maxwell.
2. Lionel Bently and Brad Sherman, Intellectual Property Law, Oxford University Press.
3. P. Narayanan, Intellectual Property Law, Eastern Law House
4. B. L. Wadehra, Law Relating to Intellectual Property, Universal Law Publishing Co.
5. V. K. Ahuja, Law Relating to Intellectual Property Rights, LexisNexis.
6. Ajit Parulekar and Sarita D'Souza, Indian Patents Law – Legal & Business Implications;Macmillan India ltd, 2006
7. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.

Reference

1. The Copyright Act, 1957
2. The Patent Act, 1970
3. The Trade Marks Act, 1999
4. The Designs Act, 2000
5. The Geographical Indication of Goods Act, 1999
6. The Protection of Plant Varieties and Farmers' Rights Act, 2001
7. The Semiconductor Integrated Circuits Layout Design Act, 2000

NP3EEBL01	Pre Dissertation Work Evaluation		9 Credits

Fourth Semester

NP4EEBL01	Dissertation Evaluation And Open Defence		17 Credits