M.Tech. (Power System Engineering)

Detailed Syllabus

Subject Code:	Subject Name:	L-T-P	Credit 3
EEM101	Power System Analysis	3- 0- 0	

COURSE OBJECTIVES:

1. To impart in-depth knowledge on different methods of power flow solutions.
2. To perform symmetrical and unsymmetrical short circuit analysis to understand the effects of different types of faults.
3. To get insight of contingency analysis problem and the solution methods.

SYLLABUS

Module-I **(9 Hours)**

Power Flow Analysis

Formulation of power flow problem - solution through Newton Raphson method - decoupled and fast decoupled power flow solutions - DC power flow solution

Module – II

Short Circuit Analysis **(9 Hours)**

Sub-transient, transient and steady state reactances of synchronous machine - symmetrical fault analysis using bus impedance matrix, symmetrical components and sequence networks, analysis of unsymmetrical fault at generator terminals, analyzing unsymmetrical faults occurring at any point in a power system.

Module – III

Contingency Analysis-I **(9 Hours)**

Importance of contingency analysis - addition / removal of one line - construction of a column of bus impedance matrix from the bus admittance matrix

Module – IV

Contingency Analysis-II **(9 Hours)**

Calculation of new bus voltages due to addition / removal of one line - calculation of new bus voltages due to addition / removal of two lines.

Module - V: **(9 Hours)**

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

Course Outcome:

1. Able to solve load flow equations using different techniques
2. Analyze symmetrical faults in power systems
3. Analyze asymmetrical faults in power system
4. Describe the state of the system

Text Books:

[1] J J Grainger and W D Stevenson, "Power System Analysis", McGrawHill, Inc., 1994.

[2] D P Kothori and I J Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education Private Limited, 2011.

References:

[3] G W Stagg and A H El Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1968.

[4] Hadi Saadat, "Power System Analysis" McGraw-Hill, 2004.

[5] M A Pai," Computer Techniques in Power System Analysis", Tata McGraw Publishing Company Limited, 2006.

DIGITAL LEARNING RESOURCES:

Course Name	Computer Aided Power System Analysis
Course Link	https://nptel.ac.in/courses/108/107/108107028/
Course Instructor	Dr. B. Das, Dr. Vinay Pant. Department of Electrical Engineering, IIT Delhi

Course Code:EEM102	**Course Name:** Power System Dynamics and Control	**L-T-P** 3-0- 0	**Credit** 3

Course Objective

CEO1: The objective of this course is to introduce the students to basic concepts of power system dynamics.

CEO2: This course will introduce the dynamic behavior of the system and its effect on the stability of the power system.

CEO3: The course will cover different types of stability analysis and methods for improving the stability.

Syllabus

Module- I **8 Hrs**

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 **8 Hrs**

Studies of parametric effect:

effect of loading, effect of K_A, 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 **6 Hrs**

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, Multimachine PEBS.

Module- IV **8 Hrs**

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.

Module- V **6 Hrs**

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

Course Outcome:

CO1: Recognize the concept of power system stability using swing equation and applies it to numerical solution and understands the concept of voltage stability and voltage collapse, midterm and long term stability

CO2: Analyze the Small Signal stability with and without controller

CO3: Computation of critical clearing time in Transient stability analysis using Energy function methods and assessment of dynamic security

CO4: Able to understand the modeling of Sub synchronous resonance

Text / Reference Books:

[1] P. Kundur, Power system stability and control, Tata McGraw-Hill, 2006

[2] P. Sauer and M. Pai, Power system dynamics and stability, Prentice Hall, 2016.

DIGITAL LEARNING RESOURCES:

Course Name	Power System Dynamics
Course Link	https://nptel.ac.in/courses/108/102/108102080/
Course Instructor	Prof. M. L. Kothari, Department of Electrical Engineering, IIT Delhi

Subject Code: EEM111	Subject Name: Grid Integration of Renewable Energy Resources	L-T-P 3-0-0	Credits 3

COURSE OBJECTIVES: The course is expected to enable the students to

1. Design and develop innovative products and services in the field of Renewable Energy.
2. Keeps abreast with the latest technology and toolset.
3. Communicate effectively to propagate ideas and promote teamwork
4. Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

Module-I: **(08 Hours)**

Power System Operation: Electric grid introduction, Supply guarantees and power quality, Stability, Effects of renewable energy into the grid, Boundaries of the actual grid configuration, Consumption models and patterns. Demand Side Management.

Distributed Generation: Definition, Integration in power system, Distributed Generation advantages and needs

Module-II: **(12 hours)**

Generation and Storage Technologies

Wind Power: Wind power generation profiles, Wind power generation advantages and disadvantages**,** Wind power generation electric features

Photovoltaic and Thermo-solar Power Photovoltaic and thermo-solar power generation profiles, photovoltaic and power generation electric features, daily/monthly generation, simulations and its comparison to building consumption.

Biomass Power, General view

Hydraulic Power: Hydroelectric centrals with asynchronous machine Hydroelectric centrals with synchronous machine Secondary regulation, Mini-hydraulic central visit

Hydrogen Technologies: State of the art (generation, transport and storage) Hydrogen applications

Power Storage: Battery types, Ultra capacitors based energy storage systems, Flywheel

Electric Vehicles: EV interests. Random generation forecast corrections EV needs according to users and grid exigencies Dimension and security according to EV needs Batteries and chargers, Standard UNE 61851. EV conductive system.

Module-III: **(10 Hours)**

Control Techniques and Renewable Energy Integration Systems

AC/DC Drives Control: Introduction to basic analysis and operation techniques on power electronic systems.

Basic commutation cell, Functional analysis of power converters main topologies, Power conversion schemes between electric machines and the grid, Power systems control using power converters, High power electronic converters. Tendencies, topologies and basic functional principles, multilevel converter with 3 stages, Electronic conversion systems application to renewable energy generation systems. Basic schemes and functional advantages. Wind Power and Photovoltaic Power applications.

Predictive direct power control of systems connected into the grid

Technological aspects of power electronic systems connection to the grid, PLL, Sampling effect, commutation frequency, Modulation types, Dimensioning LC filters, Harmonic cancellation by modulation

Active Network Devices, Control and FACTS Technology, Theory and operation principle of FACTS, Implementation and FACTS technologies, (Series / Shunt compensation)

Micro-Grids Resources evaluation and needs Dimensioning integration systems Optimizing integration systems Integration systems control, Cases of study: multi-generation buildings, Possible visit to tri-generation central

Module-IV: **(10Hours)**

Smart Grid: Background and problems of the lack of electric supply quality, Frequency variations, Slow voltage variations, Flicker voltage fluctuations, Voltage gaps and brief voltage cuts, Voltage swells, Harmonic distortion, Voltage unbalances.

Module-V:

Protective Devices: Introduction, Overcurrent protection, Distance protection, Differential protection, Protection coordination, Renewable energies protection, IEC 61850

Distributed Generation Protection: Distributed grids protection, Problems in distributed grids, Solutions.

Integration of mini- and micro-generation in distribution grids, V2G integration, Supply guarantee automatisms, Control devices, IEDs, Measurement and control communications (PLC, wireless).

COURSE OUTCOME:

After completion of the course, the student will be able to

1. Appraise the need and possibility of extracting energy and converting into electrical energy from different renewable options.
2. Describe the control techniques to integrate different renewable sources.
3. Select and design suitable configuration of smart grid.
4. Suggest, design and analyze different protective devices used for the integration of renewable sources.
5. Design and analysis of mini & micro generation.

REFERENCES BOOKS:

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017.
3. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
4. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007.

DIGITAL LEARNING RESOURCES:

Course Name	Introduction to Smart Grid
Course Link	https://nptel.ac.in/courses/108/107/108107113/
Course Instructor	Prof. N.P. Padhy, Prof. Premalata Jena, Department of Electrical Engineering, IIT Roorkee
Course Name	Dc Microgrid and Control System
Course Link	https://nptel.ac.in/courses/108/107/108107143/
Course Instructor	Prof. Avik Bhattacharya, Electrical Engineering, IIT Roorkee
Course Name	Facts Devices

Course Link	https://nptel.ac.in/courses/108/107/108107114/
Course Instructor	Prof. Avik Bhattacharya, Electrical Engineering, IIT Roorkee

Subject Code: EEM112	Subject Name: Renewable Energy Systems and Micro-grid	L-T-P 3-0-0	Credits 3

COURSE OBJECTIVES: The course is expected to enable the students to

1. Design and develop innovative products and services in the field of Renewable Energy.
2. Keeps abreast with the latest technology and toolset.
3. Communicate effectively to propagate ideas and promote teamwork
4. Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

SYLLABUS:

Module-I: **(4 Hours)**

Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Quality of Energy: Measure of Quality of energy, Identification of potential energy resources in terms of their quality. Dependency of Efficiency of energy conversion on Quality of energy. Cogeneration, Dispersed or Distributed generation.

Module-II: **(12 Hours)**

Energy from Sun: Sun- earth Geometric Relationship, Solar radiation geometry, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Sunpath diagram and evaluation of insolation quality at a location using Sunpath, Solar Thermal Energy Applications.

Solar Thermal Energy Collectors: Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar pond.

Solar Photovoltaic Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Equivalent Circuit of a PV Cell, Impact of parameters of PV cell performance, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Maximum Power Point

Tracking (MPPT), MPPT algorithms: P&O, Incremental Conductance, Efficiency of Solar Cells, Photovoltaic Panels, Shading & Mitigation techniques, Applications of Solar Cell Systems.

Module-III: **(12 Hours)**

Wind Energy Conversion System (WECs): Energy content in wind, extractible content of energy through WECs. Types of wind turbines with respect to axis of rotation (Horizontal & vertical axis wind turbine), working principle (lift and drag type) etc.

Airfoil terminology - Blade element theory - Blade design - Rotor performance and dynamics- Balancing technique (Rotor &Blade), significant parameters determining efficiency of WECs, Pitch angle, No of blades, solidity, Tip Speed ratio.

Constant speed Constant frequency - Variable speed variable frequency - Up wind-Down wind - Stall control-Pitch control - Gear coupled generator type - Direct generator drive/PMG/Rotor excited sync generator.

Module-IV: **(12 Hours)**

Integrated Energy Systems: System Aspects of Integration: voltage effects, thermal effects, fault level. Islanding. Stand Alone Systems: Network voltage and system efficiency, Case studies of standalone system. Hybrid Energy Systems and its economic evaluation. Technological aspects of power electronic systems connection to the grid. Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

Module V: Micro Grid **(8 Hours)**

Introduction to micro-grids –Types of micro-grids – Autonomous and non-autonomous grids Microgrid Components, AC and DC microgrids - Operational Framework of Microgrids - anti-islanding schemes, Economic, environmental and operational benefits of Microgrids in a distribution network, Interconnection of Microgrids.

Course Outcome:

6. Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell.
7. Describe the dynamics of wind turbine and electrical generator.
8. Select and design suitable configuration of the wind energy conversion system based on application.
9. Suggest, design and analyze hybrid energy systems.

10. Design and analysis of micro-grid.

TEXT BOOKS:

1. Non-conventional Energy Sources by G.D. Rai (Author), Khanna Publishers.
2. Renewable Energy, by Boyle, Godfrey. Oxford University Press.
3. Renewable Energy Systems – Design and Analysis with Induction Generators, by M.Godoy Simoes, Felix A.Farret, CRC press.
4. Micro-grid: A Conceptual Solution, Robert Lasseter, Paolo Piagi, PESC 2004, June 2004.

REFERENCE BOOKS:

[1] Renewable Energy Resources by John Twidell and Tony Weir, Taylor Francis Group.
[2] Renewable Energy Sources for fuels and Electricity by Laurie Barrtom, Island Press.

DIGITAL LEARNING RESOURCES:

Course Name	NOC:Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
Course Link	https://nptel.ac.in/courses/108/102/108102043/
Course Instructor	Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi, Department of Chemical Engineering, IIT Guwahati
Course Name	Non-Conventional Energy Systems
Course Link	https://nptel.ac.in/courses/108/108/108108078/
Course Instructor	Prof. L. Umanand, Electrical Engineering, IISc Bangalore

Subject Code: EEM113	Subject Name: Power Quality Improvement Techniques	L-T-P 3-0-0	Credits 3

Course Objective:

- To familiarize students with the reasons of load generated harmonics present in the supply
- To Study the methods of suppression of harmonics.

Module-I: (7hrs)

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, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions.

Module-II: (7hrs)

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, cycloconverter, transformer, rotating machines, ARC furnace, TV and battery charger.

Module-III: (6hrs)

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.

Module-IV: (8hrs)

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-V: (10hrs)

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 Books:

[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", 2nd 2008 Ed., 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 Sons. 1985

Reference Books:

[5] Dugan R. C., McGranaghan M. F. and Beaty H. W., Electrical Power System Quality", McGraw-Hill International Book Company. 1996

[6] Sankaran C., "Power Quality", CRC Press.

Subject Code: EEM121	Subject Name: Electrical Power System Transient	L-T-P 3-0-0	Credits 3

Course Objectives:

1. To give overview of nature of power system transients
2. To impart knowledge about the concept of traveling waves
3. To explain the phenomenon of switching surges and lightning surges and its modeling.
4. To impart knowledge of the criteria of insulation coordination and its standards

Syllabus

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 **(10 Hours)**

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.

Module-V **(12 Hours)**

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.

Course Outcome (CO): On the completion of the course, the student will be able

1. To understand the causes and effects of switching and lightning surges.

2. To identify the protection schemes of power system equipment from over voltages like ground wires, surge absorbers and arrestors.

3. To design of insulation of power system components

4. To carry out the insulation testing procedures

Text Books:

1. Greenwood, A., Electrical Transients in Power Systems, Wiley Inter-Science (1991).
2. Bewley, L..V., Travelling Waves on Transmission System, Power Publications Inc. (1993).

Reference Books:

1. Rudenterg, R., Electric Stroke Waves in Power Systems, Harvard University Press (1998).
2. Gonen, T., Electric Power Transmission System Engineering: Analysis and Design, John Wiley and Sons (1997).

Subject Code: EEM122	Subject Name: Analysis of Power Electronic Converters	L-T-P 3-0-0	Credits 3

Course Objective:

1. To study the operation of AC voltage converters and controllers.
2. To study the necessity requirement of power factor correction for converter circuits.
3. To study the operation of inverters with and without PWM controller.
4. To study the operation of different types of multilevel inverters.

Syllabus:

Module – I: AC voltage Controllers: (8 Hours)

Single Phase AC Voltage Controllers with PWM control only – synchronous tap changers - Three Phase AC Voltage controllers - Analysis of Controllers with star and delta connected resistive, resistive – inductive loads-Effects of source and load inductances – Application - numerical problems.

Module – II: AC-DC converters & Power Factor Correction Converters (10 Hours)

AC-DC converters

Single phase full and half Converters with inductive load – Power factor improvements: Extinction angle control - symmetrical angle control - single phase sinusoidal PWM-Single phase series converters - numerical problems - Three Phase full and half Converter with inductive load – harmonic analysis - Power factor improvements - three phase PWM-twelve pulse converters numerical problems.

Module – III: Power Factor Correction Converters: (6 Hours)

Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter.

Module – IV: PWM Inverters: (10 Hours)

Single phase full bridge inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – numerical problems - Three-Phase Inverters- Sinusoidal PWM- 60 degree PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques-current source inverters-Variable dc link inverter - numerical problems.

Module - V: Multilevel Inverters: (12 Hours) Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter-Features of Flying-Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters

Course Outcome:

After completion of this course the students will be able to:

- Analyze the operation of phase controlled converters and AC voltage converters.
- Analyze the requirements of power factor correction in converter circuits.
- Describe and analyze the operation of 3-phase inverters with and without PWM techniques.
- Describe principles of operation and features of multilevel inverters.

Text Books:

[1] Power Electronics-Md. H. Rashid –Pearson Education Third Edition- First Indian Reprint- 2008

[2] Power Electronics- Ned Mohan, Tore M. Undelan and William Robbins –John Wiley & Sons -2nd Edition.

References:

[1] Power Electronics – Lander –Ed.2009

[2] Modern power Electronics and AC Drives – B.K Bose

[3] Power Converter Circuits–William Shepherd & Li Zhang-Yes Dee Publishing Pvt. Ltd.

DIGITAL LEARNING RESOURCES:

Course Name	Analysis of Power Electronic Converters
Course Link	https://nptel.ac.in/courses/108/101/108101038/
Course Instructor	Prof. B. G Fernandes, Department of Electrical Engineering, IIT Bombay

Subject Code: EEM123	Subject Name: EHVAC	L-T-P 3-0-0	Credits 3

Syllabus

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 **(5 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.

Module- IV **(5 hrs)**

Power-frequency voltage control and overvoltages:- 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 Engineering” New Age International Publishers.

EEM105	**Research Methodology & Intellectual Property Rights**	**(2-0-0)**	**2 Credits**

Syllabus

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.

Module III:

Data Analysis : Hypothesis testing; Z-test, t-test, F-test, Chi-square test. Analysis of Variance, Non-parametric Test – Sign Test, Run test, Krushall – Wallis test. Report Writing and Presentation: Research Report, Types and significance, Structure of research report, Ethical issues in research, Presentation of report.

Module-IV

Introduction to Intellectual property: Introduction, types of intellectual property, importance of intellectual property rights. Trade Marks: Purpose and function of trade marks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark

registration processes. Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration

Module -V:

Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade screte litigation.

Text Books & References:

1. Research Methodology, C.R.Kothari
2. Research Methodology, Chawla and Sondhi, Vikas
3. Intellectual property right, Deborah, E. Bouchoux, cengage learning.
4. Intellectual property right - Unleashing the knowledge economy, Prabuddha Ganguli, Tata Mc Graw Hill Publishing Company Ltd.

Lab Code: EEM107	Laboratory Name: Power System Lab-I	L-T-P 0-0-4	Credits 2

1. Load flow analysis using ETAP software
2. Symmetrical fault analysis using ETAP software
3. Asymmetrical fault analysis using ETAP software
4. Transient stability analysis using ETAP software
5. Optimal power flow using ETAP software
6. Harmonic Analysis using ETAP software

Lab Code: EEM108	Lab Name: RESMG Lab	L-T-P 0-0-4	Credits 2

1. PV characteristics of a PV cell Under single and variable insolation.
2. PV characteristics of series and parallel connected PV modules.
3. Effects of shading on PV generation.
4. Blocking and By pass Diode mechanism for Shading of PV modules.
5. Study of battery and maintenance process through charging and discharging.
6. Understanding of the computer controlled Solar PV system.
7. Understanding of wind turbine and generator through DC motor-Induction Generator experiment at super synchronous speed.
8. MATLAB Simulation of a DFIG based wind turbine and characteristics study.
9. MATLAB Simulation of a Battery bank and its characteristics study.
10. MATLAB Simulation of a standalone PV-Wind Hybrid system.

Course Code: EEM-201	Course Name: HVDC and FACTS	L-T-P 3- 0- 0	Credit 3

Course Objectives:

- To study HVDC Transmission system
- To understand the control aspects of HVDC System
- To understand the fundamentals of FACTS Controllers,
- To know the importance of controllable parameters and types of FACTS controllers & their benefits

Syllabus:

Module – I: **[8 hours]**

HVDC transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC Converter station and various equipments. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit representation of rectifier and inverter configurations

Module – II: **[8 hours]**

Control of HVDC system: Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinction angle control. Harmonics introduction, generation, ac filters and dc filters. Introduction to multi-terminal DC systems and applications, comparison of series and parallel MTDC systems, Voltage Source Converter based HVDC systems

Module – III: [**8 hours**]

FACTS concepts: Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.

Module – IV: [**8 hours**]

Static shunt and series compensators: Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators – SVC, STATCOM, SVC and STATCOM comparison. Series compensation – objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.

Module – V: [**6 hours**]

Combined compensators: Unified power flow controller (UPFC) – Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC). Generalized and Multifunctional FACTS Controllers.

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

- Compare EHV AC and HVDC system and to describe various types of DC links
- Describe various methods for the control of HVDC systems and to perform power flow analysis in AC/DC systems
- Choose proper FACTS controller for the specific application based on system requirements
- Analyse the control circuits of Shunt Controllers, Series controllers & Combined controllers for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping

TEXT BOOKS:

- Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
- Hingorani, L.Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.

REFERENCES:

- Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
- Mohan Mathur R. and Rajiv K.Varma , 'Thyristor – based FACTS controllers for Electrical Transmission systems', IEEE press, Wiley Inter science , 2002.
- Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.
- Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS –Modeling and simulation in Power Networks' John Wiley & Sons, 2002.
- Jos Arrillaga, 'High voltage Direct Current Transmission' IET Power and Energy Series 29

DIGITAL LEARNING RESOURCES:

Course Name	HVDC and FACTS
Course Link	https://nptel.ac.in/courses/108/104/108104013/ https://nptel.ac.in/courses/108/107/108107114/
Course Instructor	Prof. S.N. Singh, Department of Electrical Engineering, IIT Kanpur (HVDC) Prof. Avik Bhattacharya, Department of Electrical Engineering, IIT Roorkee (FACTS)

Subject Code: EEM202	Subject Name: Power System Protection	L-T-P 3-0-0	Credits 3

Course Objective:

1. Grasp and apply the principles and algorithms of computer relaying in power system
2. Analyse, Compare and imbibe the efficacy of computer relaying for protection of power equipment with flexibility as well as adaptability
3. Have adequate skills to integrate appropriate protection measures for power equipment and system as a whole
4. Have commensurate technological up gradation related to state-of-the-art in power system protection

Syllabus:

Module - 1:

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.

Module - 2:

Mathematical Basis for Protective Relaying Algorithms: Use of Fourier transforms and Discrete Fourier transform for relaying purposes, Mann-Morrison technique, three sample algorithms, Differential Equation based Algorithms.

Module - 3:

Protection of power transformer, Motor protection.

Module-4:

Generator protection and distance protection of transmission lines.

Module - 5:

Numeric Protection: Introduction, block diagram of numeric relay, Numeric over current protection, Numerical transformer differential protection, Numerical distance protection of transmission lines.

Course Outcome:

1. Comprehend the evolution of computer relaying and analyze its potent applications in a synthetic way
2. Design and implement concepts of computer relaying for power equipment.

Text Books:

[1] Digital Power System Protection, S. R. Bhide, PHI Publications, 2014.

[2] Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India, 2003.

Reference Books:

[1] Computer Relaying for Power Systems, A.G. Phadke, James S. Thorp, 2nd edition, Willey Publications, 2009.

[2] T.S.M. Rao, “Digital Relay / Numerical relays “, Tata McGraw Hill, New Delhi, 2005.

[3] Bhavesh Bhalaja, R.P Maheshwari, Nilesh G.Chothani “Protection & Switchgear", Oxford Publisher, 2011.

Subject Code: EEM231	Subject Name: Energy Storage Systems	L-T-P 3-0-0	Credits 3

Course Objective:

To enable the student to understand the need for electrical energy storage, devices and technologies available and their applications

Syllabus:

Module - 1: **(8 Hours)**

Electrical Energy Storage (EES) Technologies: Characteristics of electricity, electricity and the roles of EES, high generation cost during peak-demand periods, need for continuous and flexible supply, long distance between generation and consumption, congestion in power grids, transmission by cable.

Module - 2: **(8 Hours)**

Needs for EES: Emerging needs for EES, more renewable energy, less fossil fuel, smart grid uses the roles of electrical energy storage technologies, roles from the viewpoint of utility, roles from the viewpoint of consumers, roles from the viewpoint of generators of renewable energy.

Module - 3: **(8 Hours)**

Features of EES: Classification of EES systems, mechanical storage systems, pumped hydro storage, compressed air energy storage, flywheel energy storage, electrochemical storage systems, secondary batteries, flow batteries, chemical energy storage, hydrogen, synthetic natural gas.

Module - 4: **(8 Hours)**

Types of EES Systems: Electrical storage systems, double-layer capacitors, superconducting magnetic energy storage, thermal storage systems, standards for EES, technical comparison of EES technologies.

Module - 5:

Applications of EES: Present status of applications, utility use (conventional power generation, grid operation and service), consumer use (uninterruptable power supply for large consumers), new trends in applications, renewable energy generation, smart grid, smart micro grid, smart house, electric vehicles, management and control hierarchy of storage systems, Internal configuration of battery storage systems, external connection of EES systems, aggregating EES systems and distributed generation (virtual power plant), battery SCADA– aggregation of many dispersed batteries.

Course Outcomes:

After completion of this course, the student will be able to

- analyze the characteristics of electrical energy from various sources and need for storage
- classify various types of electrical energy storage and various devices used for the purpose
- Identify various real time applications.

Text Books:

- James M. Eyer, Joseph J. Iannucci and Garth P. Corey, Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.

Reference Books:

[1] Jim Eyer, Garth Corey, Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.

[2] The Electrical Energy Storage by IEC Market Strategy Board.

Subject Code: EEM232	Subject Name: Power System Deregulation	L-T-P 3-0-0	Credits 3

COURSE OBJECTIVES:

1. To provide in-depth understanding of operation of deregulated electricity market systems.
2. To examine typical issues in electricity markets and how these are handled world-wide in various markets.
3. To enable students to analyze various types of electricity market operational and control issues using new mathematical models.

Module-I: **(12 Hours)**

Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market after effects of deregulation

Module-II: **(12 Hours)**

Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding

Module-III: **(12 Hours)**

Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, and congestion management in deregulation

Module-IV: **(08 Hours)**

General description of some ancillary services, ancillary services management in various countries, and reactive power management in some deregulated electricity markets.

Module-V: **(12 Hours)**

RELIABILITY ANALYSIS: Interruption criterion, stochastic components, component models, Calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability cost. Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market.

COURSE OUTCOMES:

After the completion of the course the student will be able to

1. Understand of operation of deregulated electricity market systems
2. Typical issues in electricity markets
3. To analyse various types of electricity market operational and control issues using new mathematical models.

TEXT BOOKS:

1. K. Bhattacharya, MHT Bollen and J.C Doolder, "Operation of Restructured Power Systems", Kluwer Academic Publishers, USA, 2001.

2. Lei Lee Lai, "Power System restructuring and deregulation", John Wiley and Sons, UK. 2001.

3. Fred I Denny and David E. Dismukes, "Power System Operations and Electricity Markets", CRC Press, LLC, 2002.

DIGITAL LEARNING RESOURCES:

Course Name	Restructured Power Systems
Course Link	https://nptel.ac.in/courses/108/101/108101005/
Course Instructor	Prof. S.A. Khaparde, Dr. A.R. Abhyankar, Department of Electrical Engineering, IIT Delhi

Subject Code: EEM233	Subject Name: Distribution System Planning and Automation	L-T-P 3-0-0	Credits 3

Course Objectives:

1: To impart knowledge of power system planning and forecasting.

2: To familiarize the students with different components of power distribution systems.

3: To impart knowledge in distribution network performance.

4: To give an understanding of modern distribution grid management.

Module-I **(8 Hours)**

Objectives of planning, long and short term planning, planning of distribution systems. Load forecasting: Classification and characteristics of loads. Approaches to load forecasting. Forecasting methodology. Short-run and long run forecasting. Time series, Econometric, end use techniques. Energy forecasting. Peak demand forecasting, total forecasting, annual and monthly peak demand.

Module-II **(8 Hours)**

Industrial and commercial distribution systems, Energy losses in distribution system, system ground for safety and protection, comparison of O/H lines and underground cable system. Distribution Network analysis: power flow, short circuit and loss calculations. Distribution system expansion planning: Configuration of distribution systems, load characteristics, design concepts, distribution transformers, distribution substation design, optimal location of substation, feeder design, design of radial lines, solution technique.

Module-III **(8 Hours)**

Voltage regulation: Application of shunt capacitance for loss reduction, System harmonics, static VAR systems, loss reduction and voltage improvement. System protection: requirements, fuses and section analyzers, over current, under voltage and under frequency protection, coordination of protective device.Operation and maintenance: Power distribution system, sub-station equipment and distribution lines, distribution transformer.Quality of supply and services: Performance benchmarking, key performance indicators, performance improvement and operation management.

Module-IV **(10 Hours)**

Distribution loss reduction and efficiency improvement: concepts and principles of distribution losses, technical loss reduction, commercial loss reduction, metering and billing system. IT applications in distribution business management: Overview of Distribution Business and Information Technology, IT Systems Applications in the Network. IT interfaces in customer services: Customer Information and Satisfaction, Metering: Issues, Concerns and Innovations, Billing: Issues, Practices and Innovations, Collection: Issues and Innovations.

Module-V **(10 Hours)**

Concepts of modern grid. Introduction to distribution automation, Layout of substations and feeders, Optimum siting and sizing of substations Distribution system load flow, configuration of distribution system, optimum capacitor placement. Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution System Automation, Distribution system monitoring and control: Concept of modern distribution systems. Smart Metering.

Text Books:

1. Turan Gonen, “Electric Power Distribution System Engineering”, CRC Press, Taylor & Francis.
2. Abdelhay A. Sallam, Om P. Malik, “Electric Distribution Systems,” Wiley-IEEE Press, May 2011.
3. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks,” IET, 2009.
4. V. Kamraju, “Electrical Power Distribution Systems”, Tata McGraw-Hill.
5. H. Lee Willis, “Power distribution planning reference book”.

EEM241	Forecasting Techniques for Power System	(3-0-0)	3 Credits

Module - 1: Introduction

The need for forecasts in electrical power system; principles of forecasting; taxonomy of forecasting techniques; univariate/multivariate forecasting; types of time-series; time-series patterns; auto-correlation function (ACF);and partial auto-correlation function (PACF).

Module - 2: Multiple Linear Regressions (MLR)

Basic definitions; MLR in matrix form; assumptions in MLR; estimation of MLR parameters using ordinary least square method; effect of omitted variable bias; maximum likelihood estimation of MLR parameters.

Module - 3: Box-Jenkins Methodology

Types of Box-Jenkins model; identifying an appropriate model: interpretation of ACF and PACF plot, preprocessing (outlier detection and correction), order identification; parameter estimation; diagnostic checking.

Module - 4: Load Forecasting-I

Key issues and challenges; components of electric load; data selection, analysis and preprocessing; feature selection; modeling, application and validation; forecasting long-term electricity demand.

Module - 5: Load Forecasting-II

Peak-demand forecasting techniques: energy and load-factor method, extrapolation of annual peak demands, modified extrapolation of annual peak demands, separate treatment of weather-sensitive component of annual peak demand, stochastic methods, comparison of methods; forecasting of load-duration curve.

Text Books:

[1] X. Wang, J. R. McDonald, Modern Power System Planning, McGraw-Hill Book Company, 1994.

[2] M. Shahidehpour, H. Yamin, Z. Li, Market Operations in in Electric Power System: forecasting, scheduling and risk mangement, John Wiley & Sons Ltd, 2002.

[3] G.P. Box and G.M. Jenkins, Time Series Analysis: Forecasting and Control, Holden-Day Inc.

Reference Books:

[1] RafalWeron, Modelling and Forecasting Electricity Loads and Prices: A statistical approach, John Wiley & Sons Ltd, 2006.

[2] S. Makridakis, S.C. Wheelwright, R.J. Hyndman, Forecasting Methods and Applications, Wiley, 1998.

Subject Code: EEM242	Subject Name: Machine Learning and Artificial Intelligence	L-T-P 3-0-0	Credits 3

Course Outcome:

1: Differentiate between Algorithmic based methods and knowledge based methods

2: Use the soft computing techniques for power system problems

3: Use appropriate AI framework for solving power system problems

4: Apply GA to power system optimization problems

Syllabus:

Module I: **(10 Hours)**

Artificial Neural Networks (ANN) – definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function.

ANN Paradigms: ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen‟s self-organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.

Module II: **(10 Hours)**

Classical and Fuzzy Sets: Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions.

Fuzzy logic controller (flc): Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets- Defuzzification methods.

Module III: **(10 Hours)**

Evolutionary Algorithms: Fundamental of Genetic Algorithm, Creation of offsprings, working principle, Encoding, Fitness Function, Reproduction, Roulette-wheel selection, Boltzmann Selection, Tournament Selection, Rank Selection, Steady State Selection, Elitism, Particle Swarm Optimization (PSO) Algorithm: Fundamentals of Particle swarm, Velocity and position updating.

Module - IV: Application of ANN and FLC **(10 Hours)**

Applications of ANN- Load flow study in power systems, Economic load dispatch, Load forecasting, Applications of ANN for power system protection, Applications of FLC- Load frequency control- Single area and two area systems- Speed control of DC motor.

Module - V: **(8 Hours)**

Application of Evolutionary Algorithms- Power loss minimization, Optimal Power flow in transmission system, Unit commitment problem solution using evolutionary algorithms.

Text Books:

[1] Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publication.

[2] Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.

References:

[1] Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.

[2] Yegnanarayana B, “Artificial Neural Networks”, Prentice hall of India Private Ltd., New Delhi, 1999.

[3] Zurada, J.M., “Introduction to Artificial Neural Systems‟, Jaico publishing house, Bombay, 1992.

[4] Zimmermann, H.J., “Fuzzy set theory and its applications‟, Allied publishers limited, Madras, 2001.

Subject Code: EEM243	Subject Name: Power System Reliability	L-T-P 3-0-0	Credits 3

Course Objectives:

4. Explain the basic reliability concepts and measures.
5. Familiar with the different types of reliability indices evaluation methods for generating systems.
6. Explain different types of reliability indices evaluation methods for transmission systems.
7. Describe the different types of reliability indices evaluation methods used in composite systems and interconnected systems.

Syllabus

Module - I

Introduction to Reliability Engineering: Definition of reliability, Probabilistic reliability, Repairable and non-repairable items, the pattern of failures with time (non-repairable and repairable items).

Module - II

Reliability Mathematics: The general reliability function, the exponential distribution, Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.

Module - III

Static Generating Capacity Reliability Evaluation: Introduction, Capacity outage probability tables, Loss of load probability (LOLP) method, Loss of energy probability(LOLE) method, Frequency and duration approach.

Module – IV

Spinning Generating Capacity Reliability Evaluation: Introduction, Spinning capacity evaluation, Derated capacity levels.

Module - V

Transmission System Reliability Evaluation: Average interruption rate method, the frequency and duration approach, Stormy and normal weather effects, The Markov processes approach, System studies.

Course Outcomes:

1. Obtain the system reliability when ‘n’ components connected in series.
2. Derive the general reliability function.
3. Analyze the reliability of transmission system

Text Books:

1. Power System Reliability Evaluations - R. Billinton, Gordon and Breach Science Publishers, New York.

2. Reliability Modeling in Electric Power Systems, J. Endrenyi, John Wiley & Sons, New York.

Reference Books

1. Practical Reliability Engineering, Patrick D.T. O'Connor, John Wiley & Sons, (Asia) Pte Ltd., Singapore.

2. Reliability of Engineering Systems - Principles and Analysis, I. Ryabinin, MIR Publishers, Moscow.

DIGITAL LEARNING RESOURCES:

Course Name	Risk and Reliability
Course Link	https://nptel.ac.in/courses/114/106/114106041/
Course Instructor	Prof. Srinivas Chandrasekaran, IIT Madras

Lab Code: EEM206	Lab Name: Power System Lab-II	L-T-P 0-0-4	Credits 2

1. To study the time current characteristics of fuse and MCB for a given network using ETAP software.
2. To study the characteristics of IDMT overcurrent relay.
3. To study the characteristics of overload relay using ETAP software.
4. Generator protection using ETAP software
5. Transformer protection using ETAP software
6. Transmission line protection using ETAP software.
7. To carry out relay coordination, calculation of TMS & PSM for a radial and ring main system using ETAP simulation.

EEM207	Artificial Intelligence Lab	(0-0-4)	2 Credits

1. Load Flow analysis in power system using artificial neural network
2. Power System State Estimations using artificial Neural Network
3. Contingency Analysis using Neural Network
4. Power system Security using Neural Network
5. Fuzzy Logic based automatic generation control (AGC) – Single area system -Two area system
6. Fuzzy Logic based small signal stability analysis
7. Simulation and verification of fuzzy Logic experiments using fuzzy logic trainer.

EEM208	**Mini Project with Seminar**	**L-T-P** **2-0-0**	**Credit 2**

Subject Code: EEM351	Subject Name: Energy Auditing and Management	L-T-P 3-0-0	Credit 3

COURSE OBJECTIVES

1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing.
2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing.

SYLLABUS

Module -I: (8 Hours)

General Aspects

General Philosophy and need of Energy Audit and Management. Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.

Module -II: (8 Hours)

Procedures and Techniques

Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering. Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation. Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation.

Module -III: (8 Hours)

Energy Policy Planning and Implementation

Key Elements: Force Field Analysis, Energy Policy-Purpose, Perspective, Contents and Formulation. Format and Ratification, Organizing: Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability. Motivating Motivation of employees, Requirements for Energy Action Planning. Information Systems: Designing, Barriers, Strategies, Marketing and Communicating Training and Planning.

Module -IV: **(5 Hours)**

Energy Balance & MIS

First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses, Improvements. Energy Balance sheet and Management Information System (MIS) Energy Modeling and Optimization.

Module -V: **(5 Hours)**

Energy Audit Instruments

Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy

COURSE OUTCOME

After completion of this course the students will be able to:

1. Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing
2. Ability to analyze the viability of energy conservation projects
3. Capability to integrate various options and assess the business and policy environment regarding energy conservation and energy auditing
4. Advocacy of strategic and policy recommendations on energy conservation and energy auditing

REFERENCE BOOKS:

1. Energy Management: W. R. Murphy, G. Mckay (Butterworths).
2. Energy Management Principles: C. B. Smith (Pergamon Press).
3. Efficient Use of Energy : I. G. C. Dryden (Butterworth Scientific)
4. Energy Economics - A. V. Desai (Wiley Eastern)
5. Industrial Energy Conservation : D. A. Reay (Pergammon Press)

6. Energy Management Handbook – W. C. Turner (John Wiley and Sons, A Wiley Interscience Publication)

7. Industrial Energy Management and Utilization – L. C. Witte, P. S. Schmidt, D. R. Brown (Hemisphere Publication, Washington)

8. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982

9. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)

10. Handbook on Energy efficiency –

11. ASHRAEE Energy Use (4 Volumes)

12. CIBSI Guide –Users Manual (U.K.) 8. CRC Handbook of Energy Efficiency – CRC Press.

DIGITAL LEARNING RESOURCES:

Course Name	Energy management system
Course Link	https://nptel.ac.in/courses/108/106/108106022/
Course Instructor	Dr. K. Shanti Swarup, Department of Electrical Engineering, IIT Madras

Subject Code: EEM352	Subject Name: Electric Vehicles	L-T-P 3-0-0	Credits 3

Course objectives:

1.Explain the basics of electric vehicles, their architecture, technologies and fundamentals.

2.Discuss different energy storage technologies used for electric vehicles and their control.

3. Analyze various electric drives suitable for electric vehicles

Module 1: **(8 Hours)**

Introduction to Electric vehicle, Introduction to electric vehicle industry, Flow chart for Designing an electric vehicle, History of electric vehicle, Electric resolution, Role of EVs in the energy transition

Module 2: **(6 Hours)**

Design Phase , working of Electric vehicles, Assumptions

Module 3: **(8 Hours)**

Types of motors, DC Motor, BLDC Motor, Advantage and disadvantage, working of BLDC out runner motor, BLDC in runner motor, Induction Motor, PMSM motor introduction, working, advantages and disadvantages

Module 4: **(8 Hours)**

Battery Fundamentals, EV Batteries, Battery calculation, Battery Management system, Battery management device

Module 5: **(8 Hours)**

Motor controllers : Introduction, Explanation, inverters and controls, charging equipment, inverter functions in electric and hybrid vehicles, working safely on electric and hybrid EV components.

Course outcomes:

1. Explain the basics of electric vehicles their architecture, technologies and fundamentals.
2. Analyze the use of different power electronic devices and electrical machines in electric vehicle
3. Explain the use of different energy storage devices used for electric vehicles their technologies and control.

Reference Books:

1. Iqbal Hussein," Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2nd Edition, 2003.
2. James Larminie, John Lowry, "Electric Vehicle Technology" Wiley Publication, 1st Edition,2003.
3. B D Mc Nicol, D A J Rand, " Power sources for Electric vehicles", Elsevier Publications, 1st Edition, 1998.

EEM353	**Advanced Control System**	**(3-0-0)**	**3 Credits**

Module - I: **(11 Hours)**

***Digital Control*:** Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Reconstruction of Original signals from sampled signals: Sampling theorem, folding, aliasing. 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.

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 Logrange 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: **(12 Hours)**

Nonlinear Systems: Lyapunov's Stability Analysis: Introduction, Lyapunov's Stability Criterion: Basic Stability Theorems, Liapunov Functions. Direct Method of Liapunov & the Linear System: Methods of constructing Liapunov functions for Nonlinear Systems.

Module - IV :

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

Module - V: **(11 Hours)**

***Fuzzy Logic and Neural Network Control*:** Fuzzy sets and crispsets, Fuzzy Relations and composition of Fuzzy Relations, Introduction to Fuzzy Logic Controllers. Introduction to artificial neural network controller.

Text / References:

[1] Discrete Time Control Systems, by K.Ogata, 2nd edition (2001), Pearson Education publication.

[2] Applied Nonlinear Control, Jean-Jacques Slotine, Massachusetts Institute of Technology, Weiping Li, Massachusetts Institute of Technology, 1991, Pearson.

[3] Digital Control Systems, by B.C. Kuo, 2nd edition (1992), Oxford University Press.

[4] Digital Control and State Variable Methods, by M.Gopal, 3rd edition (2009), Tata Mc. Graw Hill Education Pvt. Ltd.

[5] Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).

[6] Design of Feedback Control Systems by Raymond T. Stefani, B.Shalia, Clement J. Savant, Jr. Gen H. Hostetter, 4th edition (2002), Oxford University Press.

[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 & Lennart Ljung, Taylor & Francis (2009).

Subject Code: EEM361	Subject Name: Business Analytics	L-T-P 3-0-0	Credits 3

Module-1: Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Module-2: Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Module-3: Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Module-4: Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New- Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Module-5: Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Module-6:

Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Text Books:

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

Subject Code: EEM362	Subject Name: Industrial Safety	L-T-P 3-0-0	Credits 3

Module-1: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Module-2: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Module-3: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Module-4: Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment‘s like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Module-5: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair

complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Books:

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

Subject Code: EEM363	Subject Name: Operations Research	L-T-P 3-0-0	Credits 3

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

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

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

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

Module-5: 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
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

Subject Code: EEM364	Subject Name: Cost Management of Engineering Projects	L-T-P 3-0-0	Credit 3

Module-1: Introduction and Overview of the Strategic Cost Management Process

Module-2: 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: 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: 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.

Module-5: 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.

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

Subject Code: EEM365	Subject Name: Composite Materials	L-T-P 3-0-0	Credit 3

Module-1:

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

Module-2:

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

Module-3:

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

Module-4:

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

Module-5:

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

Text Books:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by

R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

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

Subject Code: EEM366	Subject Name: Waste to Energy	L-T-P 3-0-0	Credit 3

Module-1:

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

Module-2: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Module-3: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Module-4: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Module-5: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Text Books:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd.,

1991.

4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Audit Courses 1 & 2: English for Research Paper Writing

Course objectives: Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

Unit – I : **(4 Hours)**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

Unit – II : **(4 Hours)**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.

Unit – III : **(4 Hours)**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit – IV : **(4 Hours)**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

Unit – V : **(4 Hours)**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

Unit – VI : **(4 Hours)**

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.

Highman‘sbook.

4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

Audit Courses 1 & 2: Disaster Management

Course Objectives: - Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

Unit – I : **(4 Hours)**

Introduction: Disaster: Definition, Factors and Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Unit – II : **(4 Hours)**

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man┐ made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit – III : **(4 Hours)**

Disaster Prone Areas In India: Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides and Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Unit – IV : **(4 Hours)**

Disaster Preparedness And Management : Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data rom Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit – V : **(4 Hours)**

Risk Assessment: Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global

Co-Operation In Risk Assessment And Warning, People‘s Participation In Risk Assessment. Strategies for Survival.

Unit – VI : **(4 Hours)**

Disaster Mitigation: Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

Suggested readings:

1. R. Nishith, Singh AK, ―Disaster Management in India: Perspectives, issues and strategies ―‘New Royal book Company.

2. Sahni, Pardeep et.Al. (Eds.),‖ Disaster Mitigation Experiences And Reflections‖, Prentice Hall Of India, New Delhi.

3. Goel S. L., Disaster Administration And Management Text And Case Studies‖, Deep &Deep Publication Pvt. Ltd., New Delhi.

Audit Courses 1 & 2: Sanskrit for Technical Knowledge

Course Objectives:

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world

2. Learning of Sanskrit to improve brain functioning

3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power

5. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.

Unit – I : **(8 Hours)**

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences.

Unit – II : **(8 Hours)**

Order, Introduction of roots, Technical information about Sanskrit Literature.

Unit – III : **(8 Hours)**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.

Course Outcome: Students will be able to

8. Understanding basic Sanskrit language

2. Ancient Sanskrit literature about science & technology can be understood

3. Being a logical language will help to develop logic in students

Suggested reading

1. "Abhyaspustakam‖ – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi

2. Teach Yourself Sanskrit‖ Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication

3. India's Glorious Scientific Tradition‖ Suresh Soni, Ocean books (P) Ltd., New Delhi.

Audit Courses 1 & 2: Value Education

Course Objectives: Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Unit – I : **(4 Hours)**

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.

Unit – II : **(6 Hours)**

Moral and non- moral valuation. Standards and principles. • Value judgements • Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism.Love for nature,Discipline

Unit – III : **(6 Hours)**

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. Doing best for saving nature

Unit – IV : **(6 Hours)**

• Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence, Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively

Course outcomes: Students will be able to:

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

Suggested reading

1. Chakroborty, S.K. ―Values and Ethics for organizations Theory and practice‖, Oxford University Press, New Delhi

Audit Courses 1 & 2: Constitution of India

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.

2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Unit – I : **(4 Hours)**

History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working)

Unit – II : **(4 Hours)**

Philosophy of the Indian Constitution: Preamble Salient Features

Unit – III : **(4 Hours)**

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Unit – IV : **(4 Hours)**

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Unit – V : **(4 Hours)**

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit – VI : **(4 Hours)**

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and

Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Course Outcomes: Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Audit Courses 1 & 2: Pedagogy Studies

Course Objectives: Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Unit – I : **(4 Hours)**

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Unit – II : **(2 Hours)**

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Unit – III : **(4 Hours)**

Evidence on the effectiveness of pedagogical practices. Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers‘ attitudes and beliefs and Pedagogic strategies.

Unit – IV : **(4 Hours)**

Professional development: alignment with classroom practices and follow-up support Peer support, Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes

Unit – V : **(2 Hours)**

Research gaps and future directions: Research design, Contexts. Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Course Outcomes: Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested Reading:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.

5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

6. Chavan M (2003) Read India: A mass scale, rapid, _learning to read' campaign.

7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Audit Courses 1 & 2: Stress Management by Yoga

Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

Unit – I : **(4 Hours)**

Definitions of Eight parts of yog. (Ashtanga)

Unit – II : **(4 Hours)**

Yam and Niyam. Do`s and Don't's in life. (i) Ahinsa, satya, astheya, bramhacharya and aparigraha (ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit – III : **(4 Hours)**

Asan and Pranayam (i) Various yoga poses and their benefits for mind & body (ii) Regularization of breathing techniques and its effects-Types of pranayam.

Suggested Reading:

1. Yogic Asanas for Group Tarining-Part-I‖ :Janardan Swami Yogabhyasi Mandal, Nagpur
2. Rajayoga or conquering the Internal Nature‖ by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency