University Institute of Technology (UIT)

Silver Wood Estate, H. P. University, Shimla-171005

(NAAC Accredited "A-Grade" University)

DEPARTMENT
of
ELECTRICAL ENGINEERING

Course Work Syllabus

for

Doctor of Philosophy
in
Electrical Engineering

Effective from the Session 2021-2022

STRUCTURE AND SCHEME OF COURSE WORK

S.No.	SubjectCode	Course Title	L	T	P	Credit	Semester End Marks	
							External	Internal
1.	HSMC-9010	Research Methodology	4	0	0	4	100	50
2.	EE-9001	Wind & Small Hydro Energy Systems	4	0	0	4	100	50
3.	EE-9002	Distributed Generation and Micro grid	4	0	0	4	100	50
4.	EE-9003	Integrated Energy Systems	4	0	0	4	100	50
5.	EE-9004	Power Quality Monitoring: Analysis and Control	4	0	0	4	100	50
6.	EE-9005	Power System Analysis and Design	4	0	0	4	100	50
7.	EE-9006	Energy Assessment and Auditing	4	0	0	4	100	50
8.	EE-9007	Non-Conventional Energy Resources	4	0	0	4	100	50
9.	EE-9008	Applied fuzzy Electronic System	4	0	0	4	100	50
10.	EE-9009	Power Systems Restructuring and Deregulation	4	0	0	4	100	50
11.	EE-9010	Artificial Intelligence and Machine Learning	4	0	0	4	100	50
12.	EE-9011	Artificial Neural Networks	4	0	0	4	100	50

Legend:

L - Number of lecture hours per week.

T - Number of tutorial hours per week.

P - Number of practical hours per week.

C- Total no. of credit

DETAILED SYLLABUS

Name of the Course	**Research Methodology**		
Course Code	**HSMC- 9010**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculator is allowed to use in examinations.

Course Objectives

- To formulate a viable research question.
- To distinguish probabilistic from deterministic explanations.
- To analyse the benefits and drawbacks of different methodologies.
- To understand how to prepare and execute a feasible research project.

Section	Course Content
Section A	Research Aptitude: Meaning of Research, Objectives of Research, and Motivation in Research, Types of Research, Research Approaches, and Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is done. Research Process: Reviewing the literature, Formulation of research problem, Nature and type of variables, Hypothesis - meaning, types, development of hypothesis and its testing, Meaning & Functions of Research Design.
Section B	Data Analysis: Sources, acquisition and interpretation of data, Quantitative and qualitative data, Graphical representation and mapping of data, Sensitivity Analysis with Data Tables, Optimization with EXCEL Solver, Summarizing Data with Histograms and Descriptive Statistics, Pivot Tables, Summarizing Data with database statistical functions, using correlation, Multiple Regression, Using Sampling to Analyse Data

Section C	Significance of Report Writing : Different Steps in writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report, Art of scientific writing- Steps to better writing, flow method, organization of material and style, Drawing figures, graphs, tables, footnotes, references etc. in a research paper
Section D	Use of Internet in Research Work : Use of internet networks in research activities in searching material, paper downloading, submission of papers, relevant websites for journals and related research work. Introduction to Patent laws etc., process of patenting a research finding, Copy right, Cyber laws..

Course Outcomes

Upon successful completion of the course, the student will be able to

COs1: Identify and discuss the role and importance of research in the social sciences.

COs2: Identify and discuss the issues and concepts salient to the research process.

COs3: Identify and discuss the complex issues inherent in selecting a research problem

COs4: Selecting an appropriate research design, and implementing a research project.

COs5: Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.

Text Books:

1. Kothari, C. R., & quot ;Research Methodology Methods and Techniques & quot;, Wiley Eastern Ltd.
2. Wayne L. Winston, & quot; Microsoft Excel Data Analysis and Business Modelling & quot;, Microsoft Press.

Reference Books:

3. Kumar, " Research Methodology: A Step-by-Step Guide for Beginners & quot;, Pearson Education, 2018.
4. Dawson, C., Practical Research Methods UBSPD Pvt. Ltd. (2000)

Name of the Course	**Wind & Small Hydro Energy Systems**		
Course Code	**EE-9001**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculator is allowed to use in examinations.

Course Objectives

- To impart knowledge about the concept and basics of wind energy.
- Toimpartknowledgeofaerodynamictheoriesanddesignconsiderationsofwindturbine.
- To impart knowledge on small hydro power systems.

Section	Course Content
Section A	**Wind Energy Basics:** Potential of wind power in India**,** Atmospheric circulations, Classifications, Factors influencing wind, Wind shear, Turbulence, Wind resource assessment, Waybill distribution, Wind energy conversion systems, Classification, HAWT, VAWT, Components of wind turbine, Controlling of wind turbine, Wind turbine electric generator. **Aerodynamic Theories of Wind Turbine:** Axial momentum theory, Power coefficient, Axial momentum theory considering wake rotation, Blade element theory, Combined blade element momentum theory
Section B	**Wind Turbine Design Considerations:** Overview, Design procedure, Wind turbine topologies, Machine elements, Wind turbine loads, Wind turbine subsystems and components, Design evaluation, Power curve prediction.
Section C	**Small Hydro Power Systems:** Essential elements of hydroelectric power plant, Environmental issues related to large hydro projects, Potential of hydropower in India, Site selection for small hydro power, Classification of Small hydro power

Section D	**Hydraulic Component Design:** Impact of jet, Classification of hydraulic turbines, Velocity triangles, Euler's equation of turbo machine, Similarity laws of hydraulic turbines, Design calculation of Francis, Kaplan and Peloton turbines, Performance characteristics of impulse and reaction turbines, Turbines for small hydro power, Types of gate, Gate design, Governors.

Course Outcomes

Upon successful completion of the course, the student will be able to

COs1: Students will be able to understand the basic of wind energy conversion systems.

COs2: Students will be able to understand the principle of aerodynamic theories and design consideration of wind turbine.

COs3: Students will be able to understand the overview of small hydro power systems.

COs4: Students will be able to know the hydraulic component design

Text/Reference Books

1. Wind Energy Explained – Theory, Design and Application by J. F. Manwell, J. G. McGowan and A. L. Rogers, John Wiley &Sons.
2. Guide on How to Develop a Small Hydropower Plant by M. Laguna, ESHA.
3. Hydraulic Machines by K. Subramanya, TMH.
4. Introduction to Hydro Energy Systems: Basics, Technology and Operation by H. Wagner and J. Mathur, Springer.
5. Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes by A. Harvey, A. Brown and P. Hettiarachi, ITDG.

Name of the Course	**Distributed Generation and Microgrid**		
Course Code	**EE-9002**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non- programmable calculator is allowed to use in examinations.

Course Objectives

- To develop a conceptual introduction to various distributed generation systems.
- InvestigatethetechnicalchallengesofDistributedGenerationtechnologies.
- To find optimal size, placement and control aspects of DGs.
- Design the micro grid architectures and its control operation.

Section	Course Content
Section-A	Modern Power System: Generation - Transmission - Distribution - Loads - Introduction to Distributed Generation (DG) - Technologies of DG - IEEE 1547- Solar photovoltaic generation - wind energy – Wind power plants - Micro turbines - Fuel Cell - Storage Systems - batteries, fly-wheels, ultra capacitors – unit sizing of DGs - Penetration of DGs Units in Power Systems - Integration of DGs Units in Distribution Network
Section-B	Modern Power Electronics for DGs Applications – multiple and single input dc-dc converters - ac-dc and dc-ac converters - Technical restrictions - Protection of DGs - Economics of DGs –Pricing and Financing framework for DG units - Optimal placement of DGs
Section-C	Introduction to Micro grids - AC and DC micro grids - Operational Framework of Micro grids - anti-islanding schemes - Distribution Management System (DMS) - Micro grid System Central Controller (MGCC) – Local Controllers (LC)
Section-D	Economic, environmental and operational benefits of

	Microgridsinadistributionnetwork-DemandResponseManagementinMicrogrids-BusinessModelsandPricing Mechanism in Micro grids - Interconnection ofMicro grids.

Course Outcomes

Upon successful completion of the course, the students will be able to

COs1: Understand various distributed generation systems and their application in distribution system.

COs2: Design and develop modern systems for the upkeep of pollution free environment.

COs3: Utilize modern tools for modelling, analyzing and solving electrical and electronics engineering problems.

COs4: Ability to develop solutions for real-life electrical engineering problems.

Text Books

1. Renewable Energy SourcesbyJ.N. Twidell &A.D.Weir, Universitypress, Cambridge.
2. Solar Energy -Principles of Thermal Collection and Storage by S. P. Sukhatme, Tata McGraw-Hill, New Delhi.
3. Principles of Solar Engineering by F.Kreith, and J.F .Kreider,Mc-Graw-HillBook Co.
4. Direct Energy Conversion by S.L. Soo, Prentice Hall Publication.
5. Fuel Cell Systems by James Larminie, and Andrew Dicks, John Weily & SonsLtd.
6. Wind Energy Explained by J. F. Manwell, J. G. McGowan, A. L. Rogers, John Weily& Sons Ltd.
7. Power generation engineering aspects by E.J. Womack, Chapman and HallPublication.
8. Non-Conventional energy Sources by G.D. Rai, Khanna Publications, NewDelhi.
9. DistributedGeneration-Induction and Permanent Magnet Generators by Loi Lei Lai, Tze Fun Chan, IEEE Press, John Wiley & Sons, Ltd., England.
10. Microgrid: Architecture and control by N. Haziargyriou, wiley-IEEEpress.

Name of the Course	**Integrated Energy Systems**		
Course Code	**EE-9003**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. A non-programmable calculator is allowed to use in examinations.

Course Objectives

- On successful completion of this course, a student will have detailed knowledge of various major renewable energy resources and their effect on power system.
- State of the art and emerging technologies for efficient penetration and integration of renewable energyresources on power system.

Section	Course Content
Section-A	**Introduction:** Pattern of fuel consumption, Agricultural, Domestic, Industrial and community needs, Projection of energy demands, Substitution of conventional sources by alternative sources, More efficient modern technologies, Potential, Availability as well as capacity of Solar, Wind, Biogas, Natural gas, Forest produce, Tidal, Geothermal, Mini-hydro and other modern application, Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modelling to optimize different systems.
Section-B	**System Aspects of Integration:** Voltage effects, Thermal effects, Fault level, Islanding, Stand-alone systems, Network voltage and system efficiency, Case studies of stand-alone system.
Section-C	**Hybrid Energy Systems**: Hybrid energy systems and its economic evaluation, Mathematical modelling of integrated energy systems, Technological aspects of power electronic systems connection to the grid
Section-D	Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

Course Outcome:

Upon successful completion of the course, the student will be able to

COs1: Students will be able to understand the different aspects of Integrated Energy Systems.
COs2: Students will be able to understand the concept of integrated renewable energy systems.
COs3: Students will be able to understand the concept of hybrid energy systems.
COs4: Students will be able to understand the system aspects of integration

Text Books:

1. Renewable Energy Sources for fuels and Electricity by L Barrtom, IslandPress.
2. Energy Technology by T Ohta, PergamonPress.
3. Renewable Energy Resources by J Twidell and T Weir, E&FNSpon.
4. Wind-Diesel Systems by R Hunter and G Elliot, Cambridge UniversityPress.
5. Integrated Energy systems for Multigeneration by I. Dincer and Y. Bicer, ElsevierScience.

Name of the Course	**Power Quality Monitoring: Analysis and Control**		
Course Code	**EE-9004**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory will consist of a single question with 10-20 subparts of short answer type, which will cover entire syllabus and will carry 20% of the total marks of the semester end examination for course. Section A, B, C & D will have two questions from the respective sections of the syllal and each question will carry 20% of the total marks of the semester end examination for course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of sections A, B, C & D of the question paper and all the subparts of the questions in Section E. U of non-programmable calculators is allowed.

Course Objectives:

- To impart knowledge about the power quality and its assessments.
- To introduce the fundamental concepts of waveform processing techniques, monitoring of power qualities disturbances.
- To enable the students to understand how power quality studies are carried out in a distribution system.
- To enable the students to understand the factors that causes the harmonics and their effect on the power system.
- To enable the student to understand how harmonic students are carried out in a power system.
- To enable the student to understand the design concepts of grounding.

Section	Course Content
Section-A	**Overview and definition of power quality (PQ):** Sources of pollution, and regulations, Power quality problems: rapid voltage fluctuations voltage unbalance, Voltage dips and voltage swells, Short duration outage
Section-B	**Definitions Voltage sag analysis and mitigation:** Sag caused by motor starting, Sag caused by utility fault clearing, Sag mitigation, Sag magnitude and duration calculations, RMS voltage, peak Examples of sag magnitude, calculation in 1-phase systems, Harmonics: Effects-within the power system, Interference with communication Harmonic measurements. Harmonic elimination.
Section-C	**Harmonic distortion**: Power system harmonics: harmonic analysis, Harmonic

	sources-the static converters, Transformer magnetization and non-linearities, Rotating machines, arc furnaces, Fluorescent lighting. Introduction to power converters, Fourier analysis, Total harmonic distortion, rms and average value calculations, Arcing and saturable devices, Effects of harmonic distortion, System response characteristics.
Section-D	**Monitoring power quality:** Monitoring essentials, Power quality measuring equipment, Current industry trends. Power Conditioning: Electric power conditioning, Active and passive filters.

Course Outcomes:

Upon successful completion of the course, the students will be able to

COs1: Identify different power quality problems present in residential, commercial and industrial power systems.

COs2: Understand the waveform processing techniques and their applications for power quality assessment.

COs3: Apply basic principles to carry out harmonic load flow studies and the filter design concepts to mitigate harmonics.

COs4: Design a grounding mat for a substation.

TEXT BOOKS:

1. Dugan R.C. , Mcgranaghan, Electrical Power Systems Quality, McGraw Hill
2. Electric Power Quality by G. T. Heydt, Stars in a CirclePublishers.
3. Understanding Power Quality Problems by Math H. Bollen John Wiley andSons.
4. Power System Quality Assessment by J. Arrillaga and N. R. Watson John Wiley andSons
5. Power System Harmonic Analysis by J. Arrillaga, B. C. Smith, N. R. Watson & A. R. Wood JohnWiley.

Name of the Course	**Power System Analysis and Design**		
Course Code	**EE-9005**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it w consist of a single question with 10-20 subparts of short answer type, which will cover the ent syllabus and will carry 20% of the total marks of the semester end examination for the cour Section A, B, C & D will have two questions from the respective sections of the syllabus and ea question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use non-programmable calculators is allowed.

Course Objectives:

- To develop a detailed understanding of the range of analysis tools applied to the operation, design and investigation of modern electric power systems.
- To Model and predict the operation of power system components, including three phase fault studies, stability studies and power system security.
- To enable the students to understand the load flow techniques and monitoring of power system that cause the smooth and reliable operation of complex power system.

Section	Course Content
Section-A	**Network Modelling and Power Flow:** System graph, loop, cutest and incidence matrices, Y-bus formation, sparsity and optimal ordering, power flow analysis, Newton Raphson method, decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow
Section-B	**Sequential solution technique.** Fault Studies: Analysis of three phase symmetrical and unsymmetrical faults in phase and sequence domain, phase shift in sequence quantities due to transformer, open circuit faults. Stability Studies:
Section-C	Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method. **Power System Security:** Factors affecting security, State transition diagram, contingency analysis using network sensitivity method and AC power flow method.
Section-D	**State Estimation:** Introduction, power system monitoring, energy management system (EMS), SCADA, function of state estimator, maximum likelihood

	estimation.

Course Outcomes

Upon successful completion of the course, the students will be able to

COs1: Develop model of power system components suitable for various power system studies.

COs2: Carry out studies required for the modern power system operation during normal/abnormal condition.

COs3: Simulate and analyze contingencies required to ensure power system security.

COs4: Understand the hierarchy of power system control.

COs5: Understand the techniques involved in the condition monitoring of power systems.

Text Books

1. Modern Power System Analysis by D. P. Kothari and I. J. Nagrath, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. Power System Analysis by Hadi Saadat, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
3. Computer Aided Power System Analysis by George L.Kusic, Prentice Hall of India(P)Ltd., NewDelhi.
4. Computer Modelling of Electric Power System by J. Arrilaga, C. P. Arnold, B. J. Harker, John Wiley & Sons. K. Mahailnaos.
5. Understanding FACTS Concepts and Technology of Flexible AC Transmission System by N.G. Hingorani andL.Gyugyi.

Name of the Course	**Energy Assessment and Auditing**		
Course Code	**EE-9006**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed

Course Objectives:

- To develop a detailed understanding energy assessment
- To understand operation and procedure of auditing.
- To enable the students to understand the load flow techniques and monitoring of power system that cause the smooth and reliable operation of complex power system

Section	Course Content
Section-A	**Energy Scenario**: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, re-structuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act- 2001 and its features. **Basics of Energy and its various forms**: Electricity basics- DC & AC currents, electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.
Section-B	**Energy Management & Audit:** Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments.

	Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.
Section-C	**Energy Action Planning**: Key elements, force field analysis, Energy policy purpose, perspective, contents, formulation, ratification, Organizing - location of energy management, top management support, managerial function, roles and responsibilities of energy manager, accountability. Motivating-motivation of employees: Information system-designing barriers, strategies; Marketing and communicating-training and planning. **Financial Management**: Investment-need, appraisal and criteria, financial analysis techniques simple pay-back period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of ESCOs.
Section-D	**Project Management**: Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification. **Energy Monitoring, Targeting and Global environmental concerns**: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques -energy consumption, production, cumulative sum of differences (CUSUM). United Nations Framework Convention on Climate Change (UNFCC), sustainable development, Kyoto Protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), Prototype Carbon fund (PCF).

Course Outcomes:

Upon successful completion of the course, the students will be able to

COs1: Develop basics of energy

COs2: Carry out energy management and auditing.

COs3: Develop Energy Action Planning

Cos4: Understand energy monitoring

TEXT BOOKS:

1. L.C. Witte, P.S. Schmidt, D.R. Brown, “Industrial Energy Management and Utilisation” Hemisphere Publ, Washington, 1988.
2. O. Callaghn, P.W. “Design and Management for Energy Conservation”, Pergamon Press, Oxford.

REFERENCE BOOKS:

1. I.G.C. Dryden, “The Efficient Use of Energy” Butterworths, London.
2. W.C. turner, “Energy Management Hand book” Wiley, New York.
3. W.R. Murphy and G. Mc KAY “Energy Management” Butterworths, London.
4. Handbook of Energy Audits by Albert Thuman – Fairman Press Inc.
5. Energy basis for man and nature by Howard T.Odum&Elisbeth. C. Odum.

Name of the Course	**Non-Conventional Energy Resources**		
Course Code	**EE-9007**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Objectives:

- ❖ To develop a detailed understanding of non-conventional energy sources
- ❖ To understand use of green sources
- ❖ To enable the students to know energy conservation

Section	Course Content
Section-A	Introduction to Energy Sources: World energy futures, Conventional energy sources, Non-conventional energy sources, Prospects of Renewable energy sources.
Section-B	Solar Energy: Introduction to solar radiation and its measurement, Introduction to Solar energy Collectors and Storage, Solar thermal electric conversion, Thermal electric conversion systems, Solar electric power generation, Solar photo-voltaic, Solar Cell principle, Semiconductor junctions, Conversion efficiency and power output, Basic photo- voltaic system for power generation.
Section-C	Wind Energy and Wind Energy Conversion: Introduction to wind energy conversion, the nature of the wind, Power in the wind, Wind data and energy estimation, Site Selection considerations, basic Components of a Wind energy conversion system, Classification of WEC Systems
Section-D	Energy conservation-principles, technologies, waste heat utilization, heat regenerators, energy storage, devices, instruction and control.

Course Outcomes:

Upon successful completion of the course, the students will be able to

COs1: Develop basics of renewable energy

COs2: Understand solar energy and concepts

COs3: Develop wind energy understanding

Cos4: Understand energy conservation

Text Books

1. Renewable energy sources and conversion technology by N.K. Bansal, M. Kleemann, & M. Heliss, Tata McGraw-Hill.
2. Renewable Energy by S. Bent, Academic Press.
3. Renewable Energy: Power for a Sustainable Future by G. Boyle, Oxford University Press.

Name of the Course	**Applied fuzzy Electronic System**		
Course Code	**EE-9008**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of th sections A, B, C & D of the question paper and all the subparts of the questions in Section I Use of non-programmable calculators is allowed.

Course Objectives:

- To develop a detailed understanding of fuzzy logic
- To understand uncertainty in information and assess it

Section	Course Content
Section-A	History of Fuzzy Logic, Fuzzy Sets, Possibility Distributions, Fuzzy Rules, Fuzzy Sets, Operations of Fuzzy Sets, Properties of Fuzzy Sets, Geometric Interpretations of Fuzzy Sets, Possibility Theory, Fuzzy Relations and their Compositions, Fuzzy Graphs, Fuzzy Numbers, Functions with Fuzzy Arguments, Arithmetic Operations of Fuzzy Numbers.
Section-B	Fuzzy Rules: Fuzzy Mapping Rule, Fuzzy Implication Rule, Fuzzy Rule Based Models for Function Approximations, Theoretical Foundation of Fuzzy Mapping Rules, Types of Fuzzy Rule Based Models: Mamdani Model, TSK Model, Standard Additive Model, Fuzzy Implications and Approximate Reasoning: Propositional Logic, First Order Predicate Calculus, Fuzzy Implications, Approximate Reasoning, Criteria and Family of Fuzzy Implications, Possibility vs. Probability, Probability of Fuzzy Event, Probabilistic Interpretations of Fuzzy Sets, Fuzzy Measure.
Section-C	Uncertainty in information; Classical Sets, Fuzzy Sets and their properties; Cardinality of Classical Relations and their properties, The a- Level Set, Cardinality of Fuzzy Relations and their properties; Composition; Tolerance and Equivalence relationship; Membership Functions; Fuzzification and Defuzzification process; Fuzzy to Crisp Conversions; Lambda cuts; Extension

	Principle, Crisp functions and its mapping, Fuzzy functions and its mapping; Fuzzy Numbers; Internal Analysis in Arithmetic.
Section-D	Fuzzy Logic in Control Engineering: Fundamental Issues in Control Engineering, Control Design Process, Semiformal Aspects of Design Process, Mamdani Architecture of Fuzzy Control, The Sugeno-Takagi Architecture. Fuzzy Logic in Hierarchical Control Architecture, Historical Overview and Reflections on Mamdani`s Approach, Analysis of Fuzzy Control System via Lyapunov`s Direct Method, Linguistic Approach to the analysis of Fuzzy Control System, Parameter Plane Theory of Stability, Takagi-Sugeno-Kang Model of Stability Analysis.

Course Outcomes:

Upon successful completion of the course, the students will be able to

COs1: Develop basics of fuzzy logic and applications

COs2: Understand fuzzy rules

COs3: Develop understanding of fuzzy sets

COs4: Understand fuzzy logic in control engg.

Text Books:

1. J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition, 2016
2. Jeff Heaton, Introduction to the Math of Neural Network, Heaton Research

Reference Books:

1. S.S.V. Chandra, Artificial Intelligence and Machine Learning, Prentice Hall India Learning Private Limited, First edition, 2014.
2. Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning: From Theory to Algorithms c, Cambridge University, 2014.

Name of the Course	**Power System Restructuring & Deregulation**		
Course Code	**EE-9009**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Objectives:

- To impart knowledge about the restructuring and deregulation of power sector.
- To introduce the fundamental concepts relevant to OASIS, congestion management etc.
- To enable the students to understand the factors related with deregulation of power industry in different countries.

Section	Course Content
Section-A	**Introduction:** Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. Power System Restructuring: An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples. Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model.
Section-B	**Competitive electricity market:** Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing.
Section-C	**Open Access Same Time Information System (OASIS):** Introduction, structure, functionality, implementation, posting of information, uses. Congestion

	Management: Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC)
Section-D	Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC). Different Experiences in deregulation: U.S.A, Canada, U.K, Japan, Switzerland, Australia, Sweden, Germany and Indian power system.

Course Outcomes

Upon successful completion of the course, the students will be able to

COs1: Identify various concepts of restructuring and deregulation of power sector.

COs2: Describe important concepts related with deregulation like market power, OASIS, congestion management etc.

COs3: Apply principal to explain various problems related with deregulation of power sector

COs4: To understand ATC and its concepts

Text Book:

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

Name of the Course	**Artificial Intelligence and Machine Learning**		
Course Code	**EE-9010**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:

The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:

Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Objectives:

- To impart knowledge about the regression

Section	**Course Content**
Section-A	**Background and overview** Overview of terminology, formulations and concepts, Introduction of main tasks, error and performance metrics, data preparation/annotation, Components of learning, data representation, linear classification, formulation of ML problem.
Section-B	**Learnability** Hoeffding's inequality, overfitting, performance/complexity, bias/variance trade-off, End-to-End Machine Learning Project, Feature selection, Feature transformation, model selection and validation, regularization
Section-C	**Regression** Linear Regression, Polynomial Regression, Logistic Regression, Regularized Linear Models, Logistic Regression SVM and kernels Hyperplane, separation with hard margin, soft margin, support vector classification, kernel methods, support vector regression
Section-D	**Unsupervised learning:** Clustering, k-means algorithm, PCA, Neural Networks, Logistic regression, gradient descent, Perceptron, MLP, back propagation.

Course Outcomes

Upon successful completion of the course, the students will be able to

COs1: Identify various concepts of ML problem

COs2: Describe important concepts related with Learnability
COs3: Apply principal to explain various problems related with regression
COs4: To understand Unsupervised learning

Text Books:

1. J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition, 2016
2. Jeff Heaton, Introduction to the Math of Neural Network, Heaton Research

Reference Books:

1. S.S.V. Chandra, Artificial Intelligence and Machine Learning, Prentice Hall India Learning Private Limited, First edition, 2014.
2. ShaiShalev-Shwartz and Shai Ben-David, Understanding Machine Learning: From Theory to Algorithms c, Cambridge University

Name of the Course	**Artificial Neural Networks**		
Course Code	**EE-9011**	Credits-4	L-3, T-1, P-0
Total Lectures	52 (1 Hr Each) (L=39, T=13 for each semester)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Internal Assessment: (based on sessional tests 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, will consist of a single question with 10-20 subparts of short answer type, which will cover th entire syllabus and will carry 20% of the total marks of the semester end examination for th course. Section A, B, C & D will have two questions from the respective sections of the syllabu and each question will carry 20% of the total marks of the semester end examination for th course.

For Candidates:
Candidates are required to attempt five questions in all selecting one question from each of th sections A, B, C & D of the question paper and all the subparts of the questions in Section I Use of non-programmable calculators is allowed.

Course Objectives:
To impart knowledge about various technique sof artificial neural network

Section	Course Content
Section-A	A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks **Learning Process**: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process
Section-B	**Single Layer Perceptrons**: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron – Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment **Multilayer Perceptron**: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection
Section-C	**Back Propagation:** Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning
Section-D	**Self-Organization Maps (SOM):** Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Patter Classification

Course Outcomes

Upon successful completion of the course, the students will be able to
COs1: Identify various concepts of Error Correction Learning,
COs2: Describe important concepts related with Single Layer Perceptrons
COs3: Apply principal to explain various problems related with Back Propagation:
COs4: To understand Adaptive Patter Classification

Text Books:

1. Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition**.**

Reference Books:

1. Artificial Neural Networks - B. Vegnanarayana Prentice Hall of India P Ltd 2005.
2. Neural Networks in Computer Inteligance, Li Min Fu MC GRAW HILL EDUCATION 2003.
2. Neural Networks -James A Freeman David M S Kapura Pearson Education 2004.
3. Introduction to Artificial Neural Systems Jacek M. Zurada, JAICO Publishing House Ed. 2006