Curriculum for Undergraduate Degree (B.Tech.) in Electrical Engineering (w.e.f. AY: 2020-21)

Part III: Detailed Curriculum

Eighth Semester (Fourth Year)

Course Name:	**Power Quality and Deregulation**		
Course Code:	PE-EE801A	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Power System I & II and Advanced Power System
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the characteristics of AC transmission and h effect of shunt and series reactive compensation
2	To understand the working principle of FACTS devices and their operating characteristics
3	To understand the basic concepts of power quality
4	To understand the basic principle of devices to improve power quality
5	To solve numerical problems on the topics studies

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Transmission lines and series/shunt reactive power compensation: basics of AC transmission, analysis of uncompensated AC transmission analysis of uncompensated AC transmission lines. Passive reactive power compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of series and shunt compensation.	**4L**
2	Thyristor based flexible AC transmission controllers: description and characteristics of thyristor-based FACTS devices, static VAR compensator, thyristor controlled series capacitor, thyristor controlled braking resistor and single pole single throw switch, Harmonics and control of SVC and TCSC, fault current limiter.	**6L**
3	VSC based FACTS controllers: 6 pulse VSC, multi-phase and multi-level converters, PWM for VSCs, selective harmonic elimination, SPWM and Space vector modulation, STATCOM, SSSC, UPFC, IPFC, GTO controlled series compensator	**8L**

4	Application of FACTS: Application of FACTS devices for power flow control and stability improvement. Simulation example of SMIB based power swing damping using TCSC. Simulation example of voltage regulation of transmission mid-point voltage using STATCOM, DSTATCOM	**10L**
5	Power quality and De-regulation: De-regulation, power quality problems-unbalance, sag, swell, flicker, harmonics, noise, notching, dc-offsets, fluctuation, CBEMA curve.	**10L**
Total		**38L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Analyze uncompensated Ac transmission line
2	Explain working principle of FACTS
3	Apply FACTS devices for power flow control and stability
4	Apply compensation techniques using DSTATCOM

Learning Resources:	
Recommended Text Books	
1	FACTS controller in Power Transmission and Distribution, N. K. R. Padiyar, New Age International (P) Ltd., 2007
Reference Books	
1	Electrical Power Systems Quality, R. C. Dugan, McGraw Hill Education, 2012
2	Electric Power Quality, G. T. Hydt, Stars in a Circle Publications, 1991

Course Name:	**Power Plant Engineering**		
Course Code:	PE-EE 801B	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Engineering Thermodynamics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To introduce students to different aspects of power plant engineering.
2	To familiarize the students to the working of power plants based on different fuels.
3	To expose the students to the principles of safety and environmental issues.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**

1	**Introduction:** Power and energy, sources of energy, review of thermodynamic cycles related to power plants, fuels and combustion calculations. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant. Power plant economics and selection: Effect of plant type on costs, rates, fixed elements, energy elements, customer elements and investor's profit; depreciation and replacement, theory of rates. Economics of plant selection, other considerations in plant selection.	6L
2	**Steam power plant:** General layout of steam power plant, Power plant boilers including critical and super critical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems such as coal handling system, pulverizes and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power.	12L
3	**Diesel power plant:** General layout, Components of Diesel power plant, Performance of diesel power plant, fuel system, lubrication system, air intake and admission system, supercharging system, exhaust system, diesel plant operation and efficiency, heat balance, Site selection of diesel power plant, Comparative study of diesel power plant with steam power plant. Gas turbine power plant: Layout of gas turbine power plant, Elements of gas turbine power plants, Gas turbine fuels, cogeneration, auxiliary systems such as fuel, controls and lubrication, operation and maintenance.	8L
4	**Nuclear power plant:** Principles of nuclear energy, Lay out of nuclear power plant, Basic components of nuclear reactions, nuclear power station, Nuclear waste disposal, Site selection of nuclear power plants. Renewable plants: Hydroelectric station Hydrology, Principles of working, applications, site selection, classification and arrangements, hydro-electric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, interconnected systems. Non-Conventional Power Plants Introduction to non-conventional power plants (Solar, wind, geothermal, tidal)etc.	8L
5	**Electrical system:** Generators and their cooling, transformers and their cooling. Instrumentation Purpose, classification, selection and application, recorders and their use, listing of various control rooms. Pollution due to power generation.	4L
Total		**38L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe and analyze different types of sources and mathematical expressions related to ther modynamics and various terms and factors involved with power plant operation.

2	Analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts
3	Combine concepts of previously learnt courses to define the working principle of diesel power plant, its layout, safety principles and compare it with plants of other types.

Learning Resources:	
Recommended Text Books	
1	Power Plant Engineering, P.K. Nag, Tata McGraw Hill, 2002.
2	Power Plant Engineering, F.T. Morse, Affiliated East-West Press Pvt. Ltd, New Delhi/Madras, 2020.
Alternative Text Books	
3	Power Plant Technology El-Vakil, McGraw Hill, 1984.
Reference Books	
4	Steam & Gas Turbines & Power Plant Engineering by R.Yadav, Central Pub.House, 2015.
5	An introduction to thermal power plant engineering and operation, P.K.Das and A.K. Das, Notion press, 2018.

Course Name:	**High Voltage Engineering**		
Course Code:	PE-EE801C	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Electric Circuit Theory (PC-EE-301), Electromagnetic field theory (PC-EE-303), Electric Machine-I (PC-EE-401), Electrical and Electronics measurement (PC-EE-403)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the breakdown phenomenon with respect to insulators.
2	To understand the method of generation of high voltage AC and DC.
3	To understand measurement techniques of high voltage and current
4	To understand the over voltage phenomenon and insulation coordination in Electric power systems.
5	To understand different methods of high voltage testing.
6	To solve numerical problems of breakdown phenomena, generation and measurement of high voltage and currents, over voltage phenomena and high voltage testing

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**

1	**Breakdown phenomena:** Breakdown of Gases: Mechanism of Breakdown of gases, Charge multiplication, Secondary emission, Townsend Theory, Streamer Theory, Paschen's Law, Determination of Minimum breakdown voltage, Breakdown in non-uniform field, Effect of polarity on corona inception and break down voltage. Partial Discharge: definition and development in solid dielectric. Break Down of Solids: Intrinsic breakdown, Electromechanical break down, Thermal breakdown, Streamer Breakdown. Breakdown of Liquid: Intrinsic Break down, Cavitation Theory, Suspended particle Theory. Breakdown in Vacuum: Non-metallic electron emission mechanism, Clump mechanism, Effect of pressure on breakdown voltage.	**10L**
2	**Generation of High Voltage and Currents:** Generation of high DC and AC voltages: half wave rectifier circuit, Cockroft-Walton voltage multiplier circuit, Electrostatic generator, Cascaded transformers, Series resonant circuit. Generation of Impulse voltages and currents: standard impulse wave shapes, Multistage impulse generators, generation of switching surges, generation of impulse currents, tripping and control of impulse generators.	**8L**
3	**Measurement of High Voltage and Currents:** Sphere gap, Uniform field spark gap, Rod gap, Electrostatic voltmeter, Generating voltmeter, Impulse voltage measurements using voltage dividers, Measurement of High DC and Impulse currents. Cathode ray oscillographs for impulse voltage and current measurements.	**8L**
4	**Over voltage phenomenon and insulation coordination in Electric power systems:** Lightning Phenomena, Electrification of cloud, Development of Lightning Stroke, lightning induced over voltage, direct stroke, indirect stroke. Protection of Electrical Apparatus against over voltage, Lightning Arrestors, Valve Type, Metal Oxide arresters, Expulsion type. Effect of location of lightning arresters on protection of transformer. Protection of substation, Ground wires. Insulation Co-ordination, Basic Insulation level. Basic Impulse level, Switching Impulse level. Volt time characteristics of protective devices, Determination of Basic Impulse level of substation equipment.	**8L**
5	**High Voltage Testing:** Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers. High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H.V. Labs.	**6L**
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain breakdown phenomenon of composite insulators
2	a. Suggest methods for generation of high voltage and currents

	b. Suggest methods for measurement of high voltage and currents
3	Determine the basic insulation level of substation equipment.
4	a. Apply methods for the over voltage phenomenon and insulation coordination in Electric power systems. b. Check the insulation level in electric power system
5	Test insulators bushings, isolators, circuit breakers, cables and power transformers.
6	Solve numerical problems of breakdown phenomena, generation and measurement of high voltage and currents, over voltage phenomena and high voltage testing.

Learning Resources:	
Recommended Text Books	
1	High Voltage Engineering, C.L. Wadhawa, New Age International Publishers, 2012
2	High Voltage Engineering, M.S. Naidu & V. Kamraju, Tata MC Graw Hill publication. 2013
Alternative Text Books	
3	High-Voltage Engineering: theory and practice, Mazen Abdel-Salam; Hussein Anis; Ahdab El-Morshedy; Roshdy Radwan, New York, N.Y.: Marcel Dekker, 2000.
Reference Books	
4	High Voltage Engineering, E. Kuffel, W.S. Zaengl, J. Kuffel, 2nd edition, Butterworth Heinemann, 2000.

Course Name:	**HVDC Transmission**		
Course Code:	PE EE 801D	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Power Electronics Power System I Power System II
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To understand the basics of DC power transmission system.
2	To analyze HVDC converters.
3	To understand methods of control of HVDC system.
4	To understand causes of fault and protection against fault of converters.
5	To understand function of smoothing reactor and transient over voltage of DC line.
6	To understand methods of reactive power control.
7	To solve numerical problems on the topics studied.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**

1	**DC power transmission technology:** Introduction, Comparison of HVAC and HVDC transmission system, Applications of DC transmission, Description of DC transmission system, Configurations, Modern trends in DC transmission.	**4L**
2	**Analysis of HVDC converters:** Pulse number, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics, Characteristics of a twelve-pulse converter, Detailed analysis of converters with and without overlap.	**6L**
3	**Converter and HVDC system control:** General, Principles of DC link control, Converter control characteristics, System control hierarchy, Firing angle control, Current and extinction angle control, Starting and stopping of DC link, Power control, Higher level controllers.	**6L**
4	**Converter faults and protection:** Converter faults, Protection against over-currents, Overvoltage in a converter station, Surge arresters, Protection against over-voltages.	**5L**
5	**Smoothing reactor and DC line:** Introduction, Smoothing reactors, DC line, Transient over voltages in DC line, Protection of DC line, DC breakers, Mono-polar operation, Effects of proximity of AC and DC transmission lines.	**6L**
6	**Reactive power control:** Reactive power requirements in steady state, Sources of reactive power, Static VAR systems, Reactive power control during transients, Harmonics and filters, Generation of harmonics, Design of AC filters and DC filters.	**6L**
7	**Component models for the analysis of ac/dc systems:** General, Converter model, Converter control, Modeling of DC network, Modeling of AC networks.	**4L**
Total		**37L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Choose intelligently AC and DC transmission systems for the dedicated application(s).
2	Identify the suitable two-level/multilevel configuration for high power converters.
3	Select the suitable protection method for various converter faults.
4	Identify suitable reactive power compensation method.
5	Decide the configuration for harmonic mitigation on both AC and DC sides.
6	Solve numerical problems related to converters, power flow analysis, reactive power control.

Learning Resources:	
Recommended Text Books	
1	HVDC Power transmission systems, K.R. Padiyar, Third Edition, New Age International Publishers, 2017.
Alternative Text Books	
2	Power Transmission by Direct Current, Erich Uhlmann, Fourth Indian Reprint, Springer International Edition, 2012.
3	HVDC Transmission, S Kamakshaiah, V Kamaraju , 2nd Edition, Mcgraw Hill Education, 2020.
Reference Books	
1	Direct Current Transmission, E.W.Kimbark, Wiley–Blackwell; Volume 1 edition (1 January 1971).

2	H.V.D.C Transmission, J Arrillaga, 1st Edition, The Institution of Engineering and Technology, 1998.

Course Name:	**Utilization of Electric Power**		
Course Code:	PE-EE802A	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Electric Machine (PC-EE-401, PC-EE-501), Control System (PC-EE-503), Power Electronics (PC-EE-504)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand basic principle of illumination and good lighting practices
2	To understand the method of Electric heating & Welding Process.
3	To understand the concepts of Electrical traction systems.
4	To solve numerical problems on the topics studied.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Electric Traction:** Requirement of an ideal traction system, Supply system for electric traction, Train movement (speed time curve, simplified speed time curve, average speed and schedule speed), Mechanism of train movement (energy consumption, tractive effort during acceleration, tractive effort on a gradient, tractive effort for resistance, power & energy output for the driving axles, factors affecting specific energy consumption, coefficient of adhesion). Electric traction motor & their control: Parallel and series operation of Series and Shunt motor with equal and unequal wheel diameter, effect of sudden change of in supply voltage, Temporary interruption of supply, Tractive effort and horse power. Use of AC series motor and Induction motor for traction. Traction motor control: DC series motor control, Multiple unit control, Braking of electric motors, Electrolysis by current through earth, current collection in traction system, Power electronic controllers in traction system.	**12L**
2	**Electric Lighting:** Definition of terms; laws of illumination; Luminaries; Lighting requirements; Illumination levels; lamp selection and maintenance; Lighting schemes, calculations & design – Interior lighting – industrial, Factory, residential lighting; Exterior lighting - Flood, street lighting, lighting for displays and signaling - neon signs, LED-LCD displays beacons and lighting for surveillance; Energy Conservation codes for lighting; lighting controls – daylight sensors and occupancy sensors; controller design.	**10L**

3	**Electric Heating :** Advantages of electrical heating, Heating methods, Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances and thermostat control circuit ,Induction heating; principle of core type and coreless induction furnace , Electric arc heating, direct and indirect arc heating, construction, working and applications of arc furnace, Dielectric heating, applications in various industrial fields, Infra-red heating and its applications, Microwave heating, Simple design problems of resistance heating element.	**9L**
4	**Electric Welding:** Advantages of electric welding, Welding methods, Principles of resistance welding, types –spot, projection seam and butt, welding and welding equipment used, Principle of arc production, electric arc welding, characteristics of arc, carbon arc, metal arc, hydrogen arc welding and their applications, Power supply required,Advantages of using coated electrodes, comparison between AC and DC arc welding, welding control circuits, welding of aluminum and copper.	**9L**
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the fundamentals of illumination and different lighting schemes.
2	Explain the fundamental of Electric heating and Welding
3	Design appropriate lighting, heating and welding techniques for specific applications.
4	Explain the principle of different aspect of Electric traction and control of traction motor.

Learning Resources:	
Recommended Text Books	
1	Generation Distribution and Utilization of Electrical Energy, C.L. Wadhawa, New Age International Publishers, 2015
2	Art and Science of Utilization of Electrical Energy, H. Partab, Dhanpat Rai & co, 2017
Alternative Text Books	
3	Utilization of Electric Energy, E.Openahaw Taylor, Universities press, 1981
Reference Books	
4	Generation and Utilization of Electrical Energy by S. Sivanagaruju, Pearson, 2010.
5	Utilization of Electrical Energy by J. B. Gupta, Rajeev Manglik, Rohit Manglik, Kataria Publications, 2012.

Course Name:	**Process Control**		
Course Code:	PE-EE802B	**Category:**	Professional Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Control system, Measurement
Full Marks:	100		

Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To understand what is Automation : The reason for automation and its economic, industrial and social aspect.
2	To understand different forms of modulating control like feedback and feed forward control in process control. To understand essence of sequential control and its difference with modulating control.
3	To understand different control action and their advantages and working principles of different control valves and actuators.
4	To understand rudiments of PLC programming and to appreciate how PLC can be applied in industrial situation

Course Contents:

Module No.	**Description of Topic**	**Contact Hrs.**
1.	Introduction Process control & automation, Basic process control loop block diagram, servo and regulatory control, Process dynamics and mathematical modeling, Typical processes and derivation of their functions.	**8L**
2.	Characteristics and functions of different modes of control actions Analysis of On-Off, Proportional, Proportional Integral and Proportional Integral derivative (PID) control. Tuning of PID controllers, Tuning of PID controllers for FOPDT.	**7L**
3	Different control strategies-schemes, brief analysis and uses Ratio control, Cascade control, split range control, override control and multivariable control	**7L**
4	Final control element: actuators (Pneumatic actuators, Electrical actuators) and control valves (Globe, Ball. Butterfly, Gate, Pinch), different parts, Fail Position, Valve Characteristics, Valve sizing, Valve selection	**5L**
5	Introduction to Programmable Logic controllers- Basic Architecture and function, Input output modules and interfacing, CPU and memory, Relays, Timers, Counters and their uses, PLC programming and applications, Introduction to DCS	**8L**
Total		**35L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Appreciate role of automation in industry.
2	Describe the importance of sequential control and the role of PLC
3	Apply different control strategies and scheme to improve system performances and Tuning of P, PI and PID controller
4	Apply PLC in simple industrial problem using ladder diagram and logic diagram
5	Apply first order plus dead time (FOPDT) control using PID controller

Learning Resources:	
Recommended Text Books	
1	Process Control Principles and Applications : Surekha Bhanot ,Oxford Higher Education,2008.
2	Process Control Instrumentation Technology : Curtis Johnson, PHI,2000.
3	Principle of Process control, D. Patranabis, TMH, 1996.
Alternative Text Books	
5	Process Control Instrumentation Technology, C.D. Johnson, PHI, 2000.
6	Automatic Process Control, D.P. Eckman, John Wiley, 1958.
Reference Books	
7	Process Control, P. Harriott, McGraw Hill, 2017.
8	Process Dynamic & Control, S. Sundaram, Cengage Learning, 2012.
9	Process Control, S.K. Singh, PHI, 2009.

Course Name:	**Electrical Energy Conservation and Auditing**		
Course Code:	PE-EE802C	**Category:**	Professional Core Courses
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	1.Basic Electrical Engineering (ES-EE-101) 2. Electric Machine (PC-EE-401, PC-EE-501) 3. Electric Power system (PC-EE-502, PC-EE-601) 4. Control System (PC-EE-503)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To understand the basic of energy resources, energy security, energy conservation and pollution..
2	To understand the energy management concepts
3	To understand energy conservation principles and measures
4	To learn the methods of energy audit and usage of instruments

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**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, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.	**5L**

2	**Basics of Thermal Energy management** : 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	**5L**
3	**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	**6L**
4	**Energy Efficiency in Electrical Systems**: Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.	**8L**
5	**Energy Efficiency in Industrial Systems**: Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers	**10L**
6	**Energy Efficient Technologies in Electrical Systems**: Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.	**6L**
Total		**38L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the basic of energy resources, energy security, energy conservation and pollution.
2	Quantify the energy conservation opportunities in different thermal systems.
3	Quantify the energy conservation opportunities in different electrical systems.
4	Identify the common energy conservation opportunities in different energy intensive industrial equipments.
5	Explain the methods of energy management and audit.
6	Analyze and report the outcome of energy audit.

Learning Resources:
Recommended Text Books

1	Energy Management Supply and Conservation, Dr. Clive Beggs, Butterworth Heinemann, 2002.
2	Handbook of Energy Engineering, Albert Thumann & Paul Mehta, The Fairmont Press, INC, 2001.
3	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-1, General Aspects (available online), 2010.
4	Electric Energy Utilization and Conservation, S. C. Tripathy, Tata McGraw Hill, 1991.
Alternative Text Books	
5	Energy Management Handbook, Wayne C, John Willey and Sons, 2007.
6	Plant Engineers & Manager Guide to Energy Conservation, Albert, 2010.
Reference Books	
7	NPC energy audit manual and reports, 2022.
8	Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org), 2019.

Course Name:	**AI and Soft Computing**		
Course Code:	OE-CS801A	**Category:**	Open Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	BS-M101, BS-M201, BS-M301
Full Marks:			
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To learn Intelligent Agent, Search Techniques and Knowledge Representation in artificial intelligence.
2	To learn Neural Networks and applications
3	To explore Fuzzy Logic and applications
4	To explore Genetic Algorithm and applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Intelligent Agents: Introduction to Artificial Intelligence, Agents and Environments, Rationality, Nature of Environment, Structure of Agent, types of Agent Soft Computing: Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques.	**3L**
2	**Search techniques:** Problems, Problem Space & search: Defining the problem as state space search, breadth first search, depth first search, depth limited search, bidirectional search, Heuristic search strategies: Best-first search, A* search, Hill climbing search, simulated annealing search, local beam search, constraint satisfaction problems, local search for constraint satisfaction problems. Adversarial search: Games, optimal decisions & strategies in	**9L**

	games, the minimax search procedure, alpha-beta pruning, iterative deepening.	
3	**Propositional Logic Concepts:** Proposition, set of proposition, propositional calculus, alphabets of propositional calculus, wff, logical operators, precedence rules of operators, truth table method, equivalence laws, relation with natural language, FOPC, Defining predicates, Defining formula in FOPC, Scope of quantifier, Bound and free variables, closed formula, FOPL, Inference rules, PNF, FOPL formula to PNF, Skolemization	**6L**
4	**Neural Networks:** McCulloch-Pitts Neuron, Perceptron, Perceptron Learning Algorithm and Pattern classification using perceprton, Feed forward Neural Networks: Activation Functions-Hidden Layer, Activation Functions- Output Layer, Learning: Approximation of any arbitrary function, Error or Loss Function-Mean Square and Cross Entropy, Learning Algorithm-Minimization of Loss, Gradient Descent, Back propagation of error.	**6L**
5	**Fuzzy Logic:** Fuzzy vs. Crisp, Set, Venn Diagram, Cardinality, Null Set, Singleton Set, Power Set, Crisp and Fuzzy Set Properties, Membership Functions, Fuzzy Relations, Fuzzy Composition- Max-Min Composition and Max-Product Composition with examples, Fuzzification, Membership value assignments, Fuzzy to crisp conversions, Fuzzy Implication Fuzzy Rule based Systems: Aggregation of fuzzy Rules, Fuzzy Inference System-Mamdani Fuzzy Models – Sugeno Fuzzy Models. Fuzzy Logic Tools and Applications.	**6L**
6	**Genetic Algorithm:** Solving optimization problems using GA, Strings, Fitness function, Selection, Crossover, Mutation, Genetic Algorithm applications.	**6L**
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand different searching techniques in the field of AI.
2	Comprehend Propositional Logic Concepts.
3	Understand Neural Network and Applications
4	Discuss Fuzzy Logic and Applications
5	Comprehend Genetic Algorithms and Applications

Learning Resources:	
Recommended Text Books	
1	Stuart Russell, Peter Norvig, Artificial intelligence: A Modern Approach, Prentice Hall, Fourth edition, 2020.
2	Foundations Of Artificial Intelligence And Expert Systems, V S Janakiraman, Macmillan,2000.

3	Logic and Prolog Programming, Saroj Kaushik, New Age International, 2002.
4	Artificial Intelligence, Elaine Rich and K Knight, Tata McGraw Hill, 2010.
5	Samir Roy and Chakraborty, Introduction to soft computing, Pearson Edition. 2013.
6	S. Rajasekaran and G.A.VijayalakshmiPai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning, 2004.
Alternative Text Books	
7	Nils J. Nilsson, Artificial Intelligence: A New Synthesis, Morgan-Kaufmann, 1998.
8	S.N. Sivanandam, S.N. Deepa "Principles of Soft Computing" Second Edition, Wiley Publication,2011.

Course Name:	**Big Data Analytics**		
Course Code:	OE-CS801C	**Category:**	Open Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	(i) Data Base Management System (OE-EE701B) (ii)Java
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To learn the concepts of Big Data and Hadoop
2	To understand and apply the concept of HDFS and Map Reduce
3	To deal with Big Data using Hive, Pig, HBase, Impala, Sqoop

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to big data: Variety of Big Data. Big Data and its Importance of 3 V's, 4 V's, 6 V's of Big Data, Characteristics' of Big Data. Introduction of Hadoop, Benefit of Hadoop, Core Components of Hadoop, Other Components of Hadoop, Hadoop Cluster, Hadoop Start-up Mode. Introduction to HDFS, Architecture of HDFS, Role and types of Name Node, HDFS Commands.	**12L**
2	Introduction to MapReduce, Flow of Map Reduce, Word Count Problem by Using Map Reduce etc.	**4L**
3	Introduction to Hive, Architecture of Hive, Data Types of Hive, Hive Query language, Handling Complex Data Types, Scripting in Hive, Different join operations on database tables. Introduction to PIG, Data Types in Pig, Pig Latin, Scripting in Pig.	**10L**
4	Introduction to Sqoop, import data from HDFS To MySQL, Import data From Hive to MySQL. Exporting Data from Hive to Mysql.	**4L**
5	Introduction to NoSQL, Types of NoSQL Databases. Introduction to HBase. Introduction to Impala.	**6L**

Total	**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe the concept of Big Data, Hadoop and HDFS
2	Describe the concept of Map Reduce, Hive, HBase, Pig, Sqoop and Impala
3	Demonstrate the concept of data transfer between HDFS, MySQL and Hive.
4	Apply NoSQL for importing and exporting unstructured data

Learning Resources:	
Recommended Tex Books	
1	Michael Minelli, Michehe Chambers, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Business", 1st Edition, Ambiga Dhiraj, Wiely CIO Series, 2013.
2	DT Editorial Services, "Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization",Dreamtech Press India Pvt. Ltd., 2020
Alternative Text Books	
5	Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
6	Rajkumar Buyya, "Big Data Principles and Paradigms", MK,2016.
7	Tom White, "Hadoop: The Definitive Guide", 3rd Edition, O'reilly, 2012.
Reference Books	
7	Lars George, "HBase: The Definitive Guide", O'Reilley, 2011
8	Alan Gates, "Programming Pig", O'Reilley, 2011.
9	Bart Baesens "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)", John Wiley & Sons,2014

Course Name:	**Computer Network**		
Course Code:	OE-IT801A	**Category:**	Open Elective Course
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	A course on "Data Structures".
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To develop an understanding of modern network architectures from a design and Performance perspective.
2	To introduce the student to the major concepts involved in wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs).
3	To equip the students with a general overview of the concepts and fundamentals of computer networks.
4	To familiarize the students with the standard models for the layered approach to communication between machines in a network and the protocols of the various layers.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Data communication Components: Representation of data and its flow. Networks, Various Connection Topology, Protocols and Standards, OSI model, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division, and Wave division, Concepts on spread spectrum.	**8L**
2	Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back –N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols -Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA	**8L**
3	Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping – ARP, RARP, BOOTP, and DHCP–Delivery, Forwarding, and Unicast Routing protocols.	**8L**
4	Transport Layer: Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), SCTP Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.	**8L**
5	Application Layer: Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography.	**8L**
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify different types of network devices and their functions within a network.
2	Explain basic protocols of computer networks, and how they can be used for network design and implementation.
3	Solve network administration problems by applying the Computer Networking concept

Learning Resources:	
Recommended Text Books	
1	Data Communications and Networking – Behrouz A. Forouzan. Third Edition TMH, 2004.
Alternative Text Books	
2	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI, 2011.
3	An Engineering Approach to Computer Networks-S. Keshav, 2nd Edition, Pearson Education, 2002.

Reference Books	
4	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI, 2010.
5	Computer Networking: A Top-Down Approach - James Kurose and Keith Ross, Pearson ,7th edition, 2016.

Course Name:	**Internet of Things**		
Course Code:	OE-IT801C	**Category:**	Open Elective Course
Semester:	Eighth Semester	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Programming for problem solving and basic knowledge of Computer Network.
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To understand the terminology, technology and its applications
2	To understand the concept of M2M (machine to machine) with necessary protocols
3	To learn the Python Scripting Language and the Raspberry PI platform, used in many IoT devices and applications.
4	To understand the implementation of web based services on IoT devices.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Internet of Things:** Definition and characteristics of IoT, Physical design of IoT-Things in IoT, IoT Protocols, Logical Design of IoT-IoT communication models, Iot Communication APIs, **IoT enabled technologies-**Wireless sensor networks, Cloud computing, Big data analytics, Communication protocols, Embedded systems, IoT levels and deployment templates.	**10L**
2	**IoT and M2M Introduction**, M2M-Difference between IoT and M2M, SDN and NFV for IoT Software Defined Networking, Network Function Virtualization. Difference between SDN and NFV for IoT. Basics of IoT System Management with NETCOZF.	**6L**
3	**Introduction to Python:** Language features of Python, Data types, Data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling. Different Python packages.	**6L**
4	**IoT Physical Devices and Endpoints:** Introduction to Raspberry PI-Interfaces (serial, SPI, I2C). Programming-- Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, reading input from pins.	**6L**

5	**IoT Physical Servers and Cloud Offerings:** Introduction to Cloud Storage models and communication APIs. Webserver – Web server for IoT, Cloud for IoT, Python web application framework. Designing a REST full web API.	**8L**
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the definition and usage of the term "Internet of Things" in different contexts
2	Explain the key components that make up an IoT system.
3	Differentiate between the levels of the IoT stack and be familiar with the key technologies and protocols employed at each layer of the stack
4	Build and test a IoT system involving prototyping, programming and data analysis

Learning Resources:	
Recommended Text Books	
1	Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015.
2	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet nry, Pearson Education, 2017.
3	Internet of Things, K.G. Srinivasa , G.M. Siddesh, R.R. Hanumantha, CENGAGE Leaning India,2018
Alternative Text Books	
4	Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2016.
Reference Books	
5	Internet of Things (A Hands-on-Approach), Arshdeep Bahga and Vijay Madisetti, VPT, 2014.
6	Internet of Things: Architecture and Design Principles, Raj Kamal , McGraw Hill Education,2017

Course Name:	**Operational Research and Optimizing Technique**		
Course Code:	OE-M801A	**Category:**	Optional Elective Courses
Semester:	8th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	School mathematics,BS-M101,BS-M201
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To impart knowledge in concepts and tools of Operations Research
2	To understand mathematical models used in Operations Research
3	To apply these techniques constructively to make effective business decisions

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Solving Linear Programming Problems :** Formulation, Solving LPP : Using Simultaneous Equations and Graphical Method ; Simplex, Duality, Big-M method, Transportation & Assignment, Travelling Salesman problem	**11L**
2	**Game Theory** : Introduction ; 2- person Zero – sum Game; Saddle Point ; Mini-Max and Maxi-Min Theorems (statement only); Games without saddle point ; Graphical Method ; Principle of Dominance	**7L**
3	**Queuing Theory :** Introduction ; Basic Definitions and Notations ; Axiomatic Derivation of the 7L Arrival & Departure (Poisson Queue). Pure Birth and Death Models; Poisson Queue Models: M/M/1: ∞/FIFO and M/M/1: N/ FIFO.	**6L**
4	**Network Analysis :** Shortest Path : Floyd Algorithm ; Maximal Flow Problem (Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded).	**6L**
5	**Non-Linear Programming:** Integer Programming, Dynamic Programming.	**6L**
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
2	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
3	Optimize the allocation of resources to Demand points in the best possible way using various techniques and minimize the cost or time of completion of number of jobs by number of persons
4	Analyze competitive real-world phenomena using concepts from game theory. Analyze pure and mixed strategy games
5	Formulate Network models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Network problems

Learning Resources:	
Recommended Text Books	
1	H. A. Taha, "Operations Research", Pearson, 2012.

2	P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House, 1999.
3	Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency, 2011.
4	Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA, 1987.
Alternative Text Books	
5	Kanti Swaroop — "Operations Research", Sultan Chand & Sons, 2007.
6	Rathindra P. Sen—"Operations Research: Algorithms and Applications", PHI, 2009.
7	R. Panneerselvam - "Operations Research", PHI, 2006.
Reference Books	
8	A.M. Natarajan, P. Balasubramani and A. Tamilarasi - "Operations Research", Pearson, 2006.
9	M. V. Durga Prasad – "Operations Research", CENGAGE Learning, 2011.
10	J. K. Sharma - "Operations Research", Macmillan Publishing Company, 2006.

Laboratory

Course Name:	**Electrical & Electronic Design Lab-II**		
Course Code:	PW EE 881	**Category:**	
Semester:	8th	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Electric Machine I (PC-EE401) Electric Machine II (PC-EE501)
Full Marks:	100		
Examination Scheme:	Semester Examination: 100	Continuous Assessment:00	Attendance: 00

Course Objectives:	
1	To understand the circuits with instruments and safety precaution
2	To understand the design aspect of air core reactor, double circuit transmission line, wiring of residential building
3	To design the transformer and speed controller of AC machine

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Designing an air core grounding reactor with specified operating voltage, nominal current and fault current	**4P**
2	Designing a double circuit transmission line for a given voltage level and power (MVA) transfer.	**2P**
3	Wiring and installation design of a multistoried residential building (G+4,not less than 16dwelling flats with a lift and common pump)	**4P**

4	Designing an ONAN distribution transformer.	**6P**
5	Design a controller for speed control of AC machine.	**4P**
Total		**20P**

Course Outcomes:	
After completion of the course, students will be able to:	
1.	construct circuits with appropriate instruments and safety precautions
2.	design air core grounding reactor, double circuit transmission line and electric machines
3.	do wiring and installation design of a multistoried residential building with lift and pump
4.	design electronic hardware for speed of AC/DC motor

Learning Resources:	
Recommended Text Books	
1	A. K. Sawhney; A Course in Electrical Machine Design; Dhanpat Rai & Co., 2013.
2	M. G. Say: The Performance and Design of Alternating Current Machines; CBS Publishers and Distributors,2002.
Alternative Text Books	
3	S. K. Sen: Principles of Electrical Machine Design with Computer Programs ; Oxford & IBH Pub. Co., 2006.
4	M K. Giridharan, Electrical Systems Design, I. K. International Pvt Ltd, 2010.
Reference Books	
5	A.E. Clayton & N. N. Hancock: The Performance and Design of Direct Current Machines ; CBS Publishers and Distributors, 2004.

Course Name:	**Project Stage -II**		
Course Code:	PW-EE882	**Category:**	Project Work, Seminar and Internship
Semester:	8th	**Credit:**	7.5
L-T-P:	0-0-16	**Pre-Requisites:**	Knowledge on domain of project work and associated tools.
Full Marks:	100		
Examination Scheme:	Semester Examination: 100	Continuous Assessment: 00	Attendance: 00

Course Objectives:	
1	To study the content and techniques of the literature for project problem formulation.
2	To inculcate skills for team work, independent study, analysis and modeling based on literature survey and innovative thinking.
3	Planning, Preliminary Modeling, Simulation and Experiment Design (or building a prototype model) related to the topic.
4	Developing skills for writing a project report, preparing presentation on the topic and demonstrating a prototype if applicable.

Guide Line:		
Module No.	**Description of Topic**	**Contact Hrs.**
	Guide Line: **1.** This particular course would be organized as a guided assignment, which should normally include literature survey on the assigned topic. The assignment could be allocated to an individual students or small group of students. (Called hear after as team). **2.** The team would work out a preliminary approach to the Problem relating to the assigned topic. **3.** The team would Conduct Modeling, Simulation, Experiment preparation of bill of materials, project planning and design as applicable. **4.** The team would prepare a written report and presentation materials (including prototype if any) on the study conducted for presentation to the department. **5.** Individual members of the team would make oral presentation before a departmental committee as final seminar.	**100P**
Total		**100P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the content and techniques of the literature for project problem formulation.
2	Analyze the model based on literature survey and plan for innovative thinking to inculcate skills for team work
3	Plan, design of preliminary model by simulation or experiment for building a prototype related to the topic.
4	Represent project report and prepare presentation on the topic to demonstrate a prototype.

Course Name:	**Comprehensive Viva Voce**		
Course Code:	PW-EE883	**Category:**	Project Work, Seminar and Internship
Semester:	8th	**Credit:**	1
L-T-P:	0-0-0	**Pre-Requisites:**	Entire UG Syllabus
Full Marks:	100		
Examination Scheme:	Semester Examination: 100	Continuous Assessment: 00	Attendance: 00