ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ
"ವಿಟಿಯು ಅಧಿನಿಯಮ ೧೯೯೪"ರ ಅಡಿಯಲ್ಲಿ ಕರ್ನಾಟಕ ಸರ್ಕಾರದಿಂದ ಸ್ಥಾಪಿತವಾದ ರಾಜ್ಯ ವಿಶ್ವವಿದ್ಯಾಲಯ
"ಜ್ಞಾನ ಸಂಗಮ", ಬೆಳಗಾವಿ-೫೯೦೦೧೮, ಕರ್ನಾಟಕ, ಭಾರತ

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Ref: VTU/BGM/BOS/A9/2020-21 / 7024

Date: 26 MAR 2021

CIRCULAR

Subject: Updated (new addition) list of Professional and Open Elective Subjects in B.E. in Electrical & Electronics Engineering Syllabus of 2018 scheme regarding.

Reference:

1. Chairperson BOS in E&EE email dated 24.03.2021 and BOS Proceedings dated 11.02.2021
2. Hon'ble Vice-Chancellor's approval dated 26.03.2021

Concerning the subject cited above, the OPEN Elective and PROFESSIONAL Elective subjects are added to the existing list in the scheme and Syllabus of B.E. in Electrical & Electronics Engineering program. The complete list of subjects along with the syllabus is enclosed with this circular for kind reference to the concerned. And also uploaded on the VTU web portal **@ https://vtu.ac.in/en/b-e-scheme-syllabus/#menu0**

All the Principals of Engineering Colleges are hereby requested to inform the faculty of the Electrical & Electronics Engineering to counsel the students regarding the OPEN and PROFESSIONAL elective subjects

Encl: As mentioned above

Sd/-
REGISTRAR

To,

- All the Principals of the Engineering Colleges under the ambit of VTU Belagavi.

Copy to:

1. The Registrar(Evaluation) for information and needful
2. The Registrar's Office, VTU, Belagavi, for information.
3. The Special Officer, Academic Section, VTU Belagavi, for information.
4. The Special Officer CNC section to upload the circular on the VTU web portal.

26.3.2021

REGISTRAR

26/3/21

Revised Professional Electives of B.E Electrical and Electronics Engineering (EEE) and Open Electives offered by the Department of EEE.

Ref: (i) VTU/BGM/BOS/A9/2020 -21/5546 dated 29 Jan 2021
(ii) VTU/BGM/BOS/A9/2020 -21/6555 dated 8 Mar 2021
(iii) BOS meeting held on 12 – 02 – 2021 VTU/Aca/A9/2020/6017 dated 11 Feb 2021

VI semester Professional Elective -1

18EE641 Introduction to Nuclear Power
18EE642 Electrical Engineering Materials
18EE643 Computer Aided Electrical Drawing
18EE644 Embedded System
18EE645 Object Oriented Programming using C++
18EE646 Electric Vehicles Technologies
18EE647 Sensors and Transducers

VI semester Open Elective

18EE651 Industrial Servo Control Systems
18EE652 PLC and SCADA
18EE653 Renewable Energy Resources
18EE654 Introduction to Data Analytics

VII semester Professional Elective - 2

18EE731 Solar and Wind Energy
18EE732 Micro- and Nano-Scale Sensors and Transducers
18EE733 Integration of Distribution Generation
18EE734 Advanced Control Systems
18EE735 Reactive Power Control in Electric Power Systems

VII semester Professional Electives - 3

18EE741 Industrial Drives and Application
18EE742 Utilization of Electrical Power
18EE743 AI Techniques for Electric and Hybrid Electric Vehicles
18EE744 Smart Grid
18EE745 Artificial Neural Network With Applications to Power Systems

VII semester Open Elective -B

18EE751 Carbon Capture and Storage
18EE752 Electric Vehicles
18EE753 Disasters Management
18EE754 Elctrical Energy Conservation and Auditing

VIII semester Professional Electives - 4

18EE821 FACTs and HVDC Transmission
18EE822 Electrical Estimation and Costing
18EE823 Big Data Analytics in Power Systems
18EE824 Power System Planning
18EE825 Electrical Power Quality

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

INTRODUCTION TO NUCLEAR POWER (PROFESSIONAL ELECTIVE)

Course Code	18EE641	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

To explain the fission process in nuclear materials and how the nuclear reactors work and the basic components of nuclear reactors and their types.

- Explanation about cooling of reactors, features of coolant, different types of coolants used in the reactors and the losses of cooling.
- Discussion on loss of cooling accidents in different reactors.
- Discussion on postulated severe accidents in water cooled reactors and other reactors and cooling of reactor during removal and processing.
- Discussion on cooling and disposing the nuclear waste and prospect of fusion energy in the future.

Module-1

The Earth and Nuclear Power: Sources and Resources: Introduction, Earth's Internal Heat Generation, The Earth's Energy Flow, The Fission Process, Thermal Energy Resources.
How Reactors Work: Introduction, The Fission Process, Basic Components of a Nuclear Reactor, Thermal Reactors, Fast Reactors.

Module-2

Cooling Reactors: Introduction, General Features of a Reactor Coolant, Principles of Heat Transfer, Gaseous Coolants, Liquid Coolants, Boiling Coolants.
Loss of Cooling: Introduction, The Electric Kettle, Pressurized-Water Reactor, Boiling-Water Reactor, CANDU Reactor, Gas-Cooled Reactors, Sodium- Cooled Fast Reactor.

Module-3

Loss-of-Cooling Accidents: Introduction, Incidents in light Water-Cooled Reactors, Heavy Water- Moderated Reactors, Gas-Cooled Reactors, Liquid Metal-Cooled Fast Reactors.

Module-4

Postulated Severe Accidents Introduction: Introduction, Postulated Severe Accidents in Water- Cooled Reactors, Specific Phenomena relating to Severe Accidents, Severe Accidents in other Reactor Types, Fission Product Dispersion following Containment Failure.
Cooling during Fuel Removal and Processing: Introduction, Refuelling, Spent Fuel Storage and Transport, Reprocessing Plant.

Module-5

Cooling and Disposing of the Waste: Introduction, Classification of Waste Products, Fission Products and Their Biological Significance, Options for Nuclear Waste Disposal, Long-Term Storage and Disposal of Spent Nuclear Fuel, Storage and Disposal of Fission Products from Reprocessing Plants, Disposal of other Materials.
Fusion Energy -Prospect for the Future: Introduction, The Fusion Process, Confinement, Current Technical Position, Conclusions.

Course Outcomes: At the end of the course the student will be able to:

- Explain the fission process in nuclear materials, basic components of nuclear reactors, types of nuclear reactors and their working.
- List different types of coolants, their features, and cooling of reactors,
- Summarize loss of cooling accidents in different reactors.
- Discuss postulated severe accidents in reactors and cooling of reactor during removal of spentfuel.
- Discuss cooling and disposing the nuclear waste and prospect of fusion energy in the future.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Introduction to Nuclear Power	Geoffrey F. Hewitt	Taylor & Francis	1st Edition, 2000
Reference Books				
1	Nuclear Reactor Engineering	G.Vaidyanathan	S.Chand	1st Edition, 2013
2	Introduction to Nuclear Engineering	John R Lamarsh Anthony J Baratta	Pearson	3rd Edition, 2016

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

ELECTRICAL ENGINEERING MATERIALS (PROFESSIONAL ELECTIVE)

Course Code	18EE642	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To impart the knowledge of conducting, dielectric, insulating and magnetic materials and their applications.
- To impart the knowledge of superconducting materials and their applications

Module-1

Introduction to Electrical and Electronic Materials: Importance of materials, Classification of electrical and electronic materials, Scope of electrical and electronic materials, Requirement of Engineering materials, Operational requirements of electrical and electronic materials, Classification of solids on the basis of energy gap, Products – working principle and materials, Types of engineering materials, Levels of material structure. Spintronics and Spintronic materials, Ferromagnetic semiconductors, Left handed materials.

Conductors: Conductor materials, Factors affecting conductivity, Thermal conductivity, Heating effect of current, Thermoelectric effect, Seebeck effect, Thomson effect, Wiedemann – Franz law and Lorentz relation, Problems.

Module-2

Conductive Materials and Applications: Mechanically processed forms of electrical materials, Types of conducting materials, Low resistivity materials, High resistivity materials, Contact materials, Fusible materials, Filament materials, Carbon as filamentary and brush material, Material for conductors, cables, wires, solder, sheathing and sealing.

Dielectrics: Introduction to dielectric materials, classification of dielectric materials, Dielectric constant, Dielectric strength and Dielectric loss. Polarization, Mechanisms of polarization, Comparison of different polarization process, Factors affecting polarization, Spontaneous polarization, Behavior of polarization under impulse and frequency switching, Decay and build-up of polarization under ac field, Complex dielectric constant.

Module-3

Insulating Materials: Insulating materials and applications – Ceramic, Mica, Porcelain, Glass, Micanite and Glass bonded mica. Polymeric materials – Bakelite, Polyethylene. Natural and synthetic rubber. Paper. Choice of solid insulating material for different applications, Liquid insulating materials – Requirements, Transformer oil, Bubble theory, Aging of mineral insulating oils. Gaseous insulating Materials – Air, Nitrogen, Vacuum.

Magnetic Materials: Origin of permanent magnetic dipole, Magnetic terminology, Relation between relative permeability and magnetic susceptibility. Classification of magnetic materials, Diamagnetic, Paramagnetism, Ferromagnetism, Antiferromagnetic and the corresponding materials. Ferrimagnetism and ferrites – properties and applications, Soft and hard ferrites. Curie temperature, Laws of magnetic materials. Magnetization curve, Initial, and maximum permeability. Hysteresis loop and loss, Eddy current loss.

Module-4

Magnetic Materials (continued): Types of magnetic materials, Soft and hard magnetic materials, High energy magnetic materials, Commercial grade soft and hard magnetic materials.

Superconductive Materials: Concept of superconductors, Meaning of phenomenon of superconductivity, Properties of superconductors, Types of superconductors, Critical magnetic field and critical temperature, Effects of Isotopic mass on critical temperature, Silsbee rule, Depth of penetration and coherence length. Ideal and Hard superconductors, Mechanism of super conduction, London's theory for Type I superconductors, GLAG theory for Type I superconductors, BCS theory, Applications and limitations. Applications of high temperature superconductors, Superconducting solenoids and magnets, MRI for medical diagnostics.

Module-5

Plastics: Introduction, Thermoplastics, Rubbers, Thermosets, DC and AC properties, Mechanical properties and processing of plastic.

Materials for Opto – Electronic Devices: Introduction, Optical phenomena, Reflection, Refraction, Transmittivity, Scattering, Optical absorption, Optical properties of non-metals, Optical properties of metals, Optical properties of semiconductors, Optical properties of insulators. Luminescence, Opto – Electronic devices, Photoconductivity, Photoconductive cell.

Course Outcomes: At the end of the course the student will be able to:

- Discuss electrical and electronics materials, their importance, classification and operational requirement
- Discuss conducting, dielectric, insulating and magnetic materials used in engineering, their properties and classification.
- Explain the phenomenon superconductivity, super conducting materials and their application in engineering.
- Explain the plastic and its properties and applications.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Advanced Electrical and Electronics Materials; Processes and Applications	K.M. Gupta, Nishu Gupta	Wiley	1st Edition, 2015
Reference Books				
1	Electronic Engineering Materials	R.K. Shukla, Archana Singh	McGraw Hill	2012
2	Electrical Properties of Materials	L Solymar et al	Oxford	9th Edition, 2014
3	Electrical Engineering Materials	A.J. Dekker	Pearson	2016
4	Principle of Electronic Materials and Devices	S.O. Kasap	McGraw Hill	3rd Edition 2010

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

COMPUTER AIDED ELECTRICAL DRAWING (PROFESSIONAL ELECTIVE)

Course Code	18EE643	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To discuss the terminology of DC and AC armature windings.
- To discuss design and procedure to draw armature winding diagrams for DC and AC machines.
- To discuss the substation equipment, their location in a substation and development of a layout for substation.
- To discuss different sectional views of transformers, DC machine, its parts and alternator and itsparts.
- To explain development of sectional views of Transformers, DC machine and alternators usingthe design data, sketches.

Suitable CAD software can be used for drawings

PART - A

Module-1

Winding Diagrams:

(a) Developed Winding Diagrams of D.C. Machines: Simplex Double Layer Lap and Wave Windings.
(b) Developed Winding Diagrams of A.C. Machines:
(c)Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings.
(d) Single Layer Windings – Un-Bifurcated 2 and 3 Tier Windings, Mush Windings, Bifurcated 3 Tier Windings.

Module-2

Single Line Diagrams: Single Line Diagrams of Generating Stations and Substations Covering Incoming Circuits, Outgoing Circuits, Busbar Arrangements (Single, Sectionalised Single, Main and Transfer, Double Bus Double Breaker, Sectionalised Double Bus, One and a Half Circuit Breaker Arrangement, Ring Main),Power Transformers, Circuit Breakers, Isolators, Earthing Switches, InstrumentTransformers, Surge or Lightning Arresters, Communication Devices (Power- Line Carrier) and Line Trap.

Module-3

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:
Transformers - Sectional Views Of Single And Three Phase Core And Shell Type Transformers.

Module-4

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:
D.C. Machine - Sectional Views of Yoke with Poles, Armature and Commutator dealt separately.

Module-5

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:
Alternator – Sectional Views of Stator and Rotor dealt separately.

Course Outcomes: At the end of the course the student will be able to:

- Develop armature winding diagram for DC and AC machines
- Develop a Single Line Diagram of Generating Stations and substation using the standard symbols.
- Construct sectional views of core and shell types transformers using the design data
- Construct sectional views of assembled DC and AC machine and their parts using the design data or the sketches

Question paper pattern:

- The question paper will have two parts, PART – A and PART – B.
- Each part is for 50 marks.
- Part A is for Modules 1 and 2.
- Questions 1 and 2 of PART - A will be only on DC windings or only on AC windings. Students have to answer any one of them. The marks prescribed is 25.
- Question 3 of PART – A covering module 2 is compulsory. The marks prescribed is 15.
- Part B is for Modules 3, 4 and 5.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Reference Books				
1	A course in Electrical Machine design	A. K. Sawhney	DhanpatRai	6th Edition, 2013
	Electrical Engineering Drawing	K. L. Narang	Satya Prakashan	2014

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

EMBEDDED SYSTEMS (PROFESSIONAL ELECTIVE)

Course Code	18EE644	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concepts of Embedded system design such as ROM variants, RAM, SOC
- To learn the technological aspects of Embedded system such as signal conditioning, Sample & Hold.
- To understand the design trade-offs.
- To study about the software aspects of Embedded system.

Module-1

Concept of Embedded System Design: Components, classification, skills required. Embedded Micro controller cores: Architecture of 6808 and 6811. Embedded Memories ROM variants, RAM. [Textbook -3 and Reference book -3]

Module-2

Technological Aspects of Embedded System: Applications of embedded system: Examples of Embedded systems SOC for bar code scanner. Interfacing between analog and digital blocks, Signal conditioning, digital signal processing, DAC & ADC interfacing, Sample & hold, multiplexer interface Internal ADC interfacing (excluding 6805 & 6812). [Textbook -1]

Module-3

Design Trade Offs Due to Process Incompatibility, Thermal Considerations: Data Acquisition System and Signal conditioning using DSP . Issues in embedded system design. Design challenge, design technology, trade-offs. Thermal considerations. [Reference book -1and Internet Sources]

Module-4

Software aspects of Embedded Systems: Real time programming Languages, operating systems. Programming concepts and embedded programming in C. Round Robin, Round Robin with interrupts, function queue-scheduling architecture. [Textbook -3 and Reference book -3]

Module-5

Subsystem interfacing: With external systems user interfacing, Serial I/O devices, Parallel port interfaces: Input switches, Key boards and Memory interfacing. [Textbook -1]

Course Outcomes: At the end of the course the student will be able to:

- Identify the Embedded system components.
- Apply technological aspects to various interfacing with devices.
- Elaborate various design trade-offs.
- Apply software aspects and programming concepts to the design of Embedded System.
- Explain how to interface subsystems with external systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Embedded Microcomputer systems: Real time interfacing	Valvano J.W	Cengage Learning,	2nd Edition

2	The Art of Designing Embedded systems	Jack Ganssle	Newnes	2nd Edition, 2008
3	Embedded System, Architecture, Programming and Design	Raj Kamal	TMH,	2nd Edition 2008
Reference Books				
1	A Unified Hardware/Software Introduction	Frank Vahid, Tony Givargis	Wiley	student edition 2002
2	Motorola and Intel Manuals			
3	Embeded Software Premier	Simon David	Addison Wessly	2000

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

OBJECT ORIENTED PROGRAMMING USING C++ (PROFESSIONAL ELECTIVE)

Course Code	18EE645	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Define Encapsulation, Inheritance and Polymorphism.
- Solve the problem with object oriented approach.
- Analyze the problem statement and build object oriented system model.
- Describe the characters and behavior of the objects that comprise a system.
- Explain function overloading, operator overloading and virtual functions.
- Discuss the advantages of object oriented programming over procedure oriented programming.

Module-1

Beginning with C++ and its Features:
What is C++?, Applications and structure of C++ program, Different Data types, Variables, Different Operators, expressions, operator overloading and control structures in C++ . (Topics from Chapter 2 and 3 of textbook]

Module-2

Functions, Classes and Objects:
Functions, Inline function, function overloading, friend and virtual functions, Specifying a class, C++ program with a class, arrays within a class, memory allocation to objects, array of objects, members, pointers to members and member functions. (Selected Topics from Chapter 4 and 5 of textbook).

Module-3

Constructors, Destructors and Operator Overloading: Constructors, Multiple constructors in a class, Copy constructor, Dynamic constructor, Destructors, Defining operator overloading, Overloading Unary and binary operators, Manipulation of strings using operators. (Selected topics from Chapter 6 and 7 of textbook).

Module-4

Inheritance, Pointers, Virtual Functions, Polymorphism:
Derived Classes, Single, multilevel, multiple inheritance, Pointers to objects and derived classes, this pointer, Virtual and pure virtual functions (Selected topics from Chapter 8 and 9 of textbook).

Module-5

Streams and Working with Files:
C++ streams and stream classes, formatted and unformatted I/O operations, Output with manipulators, Classes for file stream operations, opening and closing a file, EOF (Selected topics from Chapters 10 and 11 of textbook).

Course Outcomes: At the end of the course the student will be able to:

- Explain the basics of Object Oriented Programming concepts.
- Apply the object initialization and destroy concept using constructors and destructors.
- Apply the concept of polymorphism to implement compile time polymorphism in programs by using overloading methods and operators.
- Utilize the concept of inheritance to reduce the length of code and evaluate the usefulness.
- Apply the concept of run time polymorphism by using virtual functions, overriding functions and abstract class in programs.
- Utilize I/O operations and file streams in programs.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Object Oriented Programming with C++	E.Balaguruswamy	TMH	6th Edition, 2013
Reference Books				
1	ObjectOriented Programming with C++	Robert Lafore	Galgotia publication	2010
2	ObjectOriented Programming with C++	Sourav Sahay	Oxford University	2006

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

ELECTRIC VEHICLE TECHNOLOGIES (PROFESSIONAL ELECTIVE)

Course Code	18EE646	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand working of Electric Vehicles and recent trends.
- Ability to analyze different power converter topology used for electric vehicle application.
- Ability to develop the electric propulsion unit and its control for application of electric vehicles.
- Ability to design converters for battery charging and explain transformer less topology.

Module-1

Electric and Hybrid Electric Vehicles: Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains.

Module-2

Energy storage for EV and HEV: Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modelling of PEMFC, Supercapacitors.

Module-3

Electric Propulsion: EV consideration, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives.

Module-4

Design of Electric and Hybrid Electric Vehicles: Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design.

Module-5

Power Electronic Converter for Battery Charging: Charging methods for battery, Termination methods, charging from grid, The Z-converter, Isolated bidirectional DC-DC converter, Design of Z- converter for battery charging, High-frequency transformer based isolated charger topology, Transformer less topology.

Course Outcomes: At the end of the course the student will be able to:

- Explain the working of electric vehicles and recent trends.
- Analyze different power converter topology used for electric vehicle application.
- Develop the electric propulsion unit and its control for application of electric vehicles.
- Design converters for battery charging and explain transformer less topology.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals,	M. Ehsani, Y. Gao, S. Gay and Ali Emadi	CRC Press	2005

2	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Husain	CRC Press	2003
Reference Books				
1	Energy Management Strategies for Electric and Plug-in Hybrid Electric	Sheldon S. Williamson	Springer	2013
2	Modern Electric Vehicle Technology	C.C. Chan and K.T. Chau	Oxford University	2001
3	Hybrid Electric Vehicles Principles And Applications With Practical Perspectives	Chris Mi, M. Abul Masrur, David Wenzhong Gao	Wiley Publication	2011

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

SENSORS AND TRANSDUCERS (PROFESSIONAL ELECTIVE)

Course Code	18EE647	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Explain the use of gauges and transducers to measure pressure, direction, distance and electromagnetic radiations
- Explain the transducers used for temperature sensing, and for the measurement of sound.
- Explain the sensors and transducers used for the measurement of mass, volume and environmental quantities.

Module-1

Strain and Pressure: Mechanical strain, Interferometry, Fibre optic methods, pressure gauges, low gas pressures, Ionization gauges, Transducer use.
Position, direction, distance, and motion: Position, Direction, Distance measurement, Distance travelled, Accelerometer systems, Rotation.

Module-2

Light and associated radiation: Nature of light, Colour temperature, Light flux, Photosensors, Photoresistors and photoconductors, Photodiodes, Phototransistors, Photovoltaic devices, Fibre – optic applications, Light transducers, Solid-state transducers, Liquid crystal displays (LCD), Light valves, Image transducers, Radio waves.

Module-3

Temperature sensors and thermal transducers: Heat and temperature, The bimetallic strip, Liquid and gas expansion, Thermocouples, Metal – resistance sensors, Thermistors, Radiant heat energy sensing, Pyroelectric detectors, Thermal transducers, Thermal to electrical transducers.

Module-4

Sound, infrasound and ultrasound: Principles, Audio electrical sensors and transducers, Electrical to audio transducers.

Module-5

Solids, liquids and gases: Mass and volume, Electronic sensors, Proximity detectors, Liquid levels, Liquid flow sensors, Timing, Gases, Viscosity.
Environmental Sensors: Environmental quantities, Time, Moisture, Acidity/alkalinity, Wind chill, Radioactive count rate, Surveying and security, Animal fat thickness, Water purity, Air purity, Smoke and fire detectors, Building acoustics.

Course Outcomes: At the end of the course the student will be able to:

- Use gauges and transducers to measure pressure, direction and distance.
- Discuss the use of light transducers and other devices used for the measurement of electromagnetic radiations.
- Explain the working of different temperature sensing devices.
- Discuss the principles and applications of audio electrical sensors and transducers used for the measurement of sound.
- Discuss the use of sensors for the measurement of mass, volume and environmental quantities.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbook				
1	Sensors and Transducers	Ian R. Sinclair	Newnes	3rd Edition, 2001

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

INDUSTRIAL SERVO CONTROL (OPEN ELECTIVE)

Course Code	18EE651	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- To explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- To discuss system analogs and vectors, with a review of differential equations.
- To discuss the concept of transfer functions for the representation of differential equations.
- To discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- To represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.
- To determine the frequency response techniques for proper servo compensation.

Module-1

Servos: Introduction, Benefits of Servo Systems, Types of Servos - Evolution of Servo Drives, Classification of Drives, Components of Servos - Hydraulic/Electric Circuit Equations, Actuators- Electric, Actuators-Hydraulic,Amplifiers-Electric,Amplifiers-Hydraulic,Transducers (Feedback).

Module-2

Machine Servo Drives: Types of Drives, Feed Drive Performance.
Troubleshooting Techniques: Techniques by Drive, Problems: Their Causes and Cures.
Machine Feed Drives: Advances in Technology, Parameters for making Application Choices.
Application of Industrial Servo Drives: Introduction ,Physical System Analogs, Quantities and Vectors, Differential Equations for Physical Systems, Electric Servo Motor Transfer Functions and Time Constants, Transport Lag Transfer Function, Hydraulic Servo Motor Characteristics, General Transfer Characteristics.

Module-3

Generalized Control Theory: Servo Block Diagrams, Frequency-Response Characteristics and Construction of Approximate (Bode) Frequency Charts, Nichols Charts, Servo Analysis Techniques, Servo Compensation.
Indexes of Performance: Definition of Indexes of Performance for Servo Drives, Indexes of Performance for Electric and Hydraulic Drives.

Module-4

Performance Criteria: Percent Regulation, Servo System Responses.
Servo Plant Compensation Techniques: Dead-Zone Nonlinearity, Change-in-Gain Nonlinearity, Structural Resonances, Frequency Selective Feedback, Feed forward Control.
Machine Considerations: Machine feed drive Considerations, Ball Screw Mechanical Resonances and Reflected Inertias for Machine Drives.

Module-5

Machine Considerations: Drive Stiffness, Drive Resolution, Drive Acceleration, Drive Speed Considerations, Drive Ratio Considerations, Drive Thrust/Torque And Friction Considerations, Drive Duty Cycles.

Course Outcomes: At the end of the course the student will be able to:

- Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- Discuss system analogs, vectors and transfer functions of differential equations.
- Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- Represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.

- Determine the frequency response techniques for proper servo compensation.
- Explain perform indices and performance criteria for servo systems and discuss the mechanical considerations of servo systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Industrial Servo Control Systems Fundamentals and Applications	George W. Younkin	Marcel Dekker	1st Edition, 2003
Reference Books				
1	Servo Motors and Industrial Control	Riazollah Firoozian	Springer	2nd Edition, 2014
2	DC SERVOS Application and Design with MATLAB	Stephen M. Tobin	CRC	1st Edition, 2011

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

PLC AND SCADA (OPEN ELECTIVE)

Course Code	18EE652	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

•To explain advantages and disadvantages, main parts and their functions, basic sequence of operation of PLC.

• To describe the hardware components: I/O modules, CPU, memory devices, other support devices and the functions of PLC memory map.

• To describe program scan sequence, the communication of information to the PLC using different languages, internal relay instruction.

• To explain identification of common operating modes found in PLCs, writing and entering the ladder logic programs.

• To define the functions of Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-in circuits and Latching Relays.

• To explain conversion of relay schematics into PLC ladder logic programs and writing PLC programs directly from narrative descriptions.

•To explain the functions of PLC counter instructions, applying combinations of counters and timers to control systems.

•To describe the function of selectable timed interrupt and fault routine files and use of temporary end instruction.

•To explain the execution of data transfer instructions, interruption of data transfer and data compare instructions.

• To explain the basic operation of PLC closed-loop control system, various forms of mechanical sequencers and their operations.

•To describe the operation of bit and word shift registers and develop programs that use shift registers.

•To discuss the operation of various processes, structures of control systems and the method of communication between different industrial processes.

Module-1

Programmable Logic Controllers: Introduction, Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Application.

PLC Hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, The Central Processing Unit (CPU), Memory Design, Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs).

Basics of PLC Programming: Processor Memory Organization, Program Scan, PLC Programming Languages, Relay-Type Instructions, Instruction Addressing, Branch Instructions, Internal Relay Instructions, Programming Examine If Closed and Examine If Open Instructions, Entering the Ladder Diagram, Modes of Operation.

Module-2

Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic Control Relays, Contactors, Motor Starters, Manually Operated Switches, Mechanically Operated Switches, Sensors, Output Control Devices, Seal-In Circuits, Latching Relays, Converting Relay Schematics into PLC Ladder Programs, Writing a Ladder Logic Program Directly from a Narrative Description.

Programming Timers: Mechanical Timing Relays, Timer Instructions, On-Delay Timer Instruction, Off-Delay Timer Instruction, Retentive Timer, Cascading Timers.

Module-3

Programming Counters: Counter Instructions, Up-Counter, Down-Counter, Cascading Counters, Incremental Encoder-Counter Applications, Combining Counter and Timer Functions.

Program Control Instructions: Master Control Reset Instruction, Jump Instruction, Subroutine Functions, Immediate Input and Immediate Output Instructions, Forcing External I/O Addresses, Safety Circuitry, Selectable Timed Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction.

Module-4

Data Manipulation Instructions: Data Manipulation, Data Transfer Operations, Data Compare Instructions, Data Manipulation Programs, Numerical Data I/O Interfaces, Closed-Loop Control.
Math Instructions: Math Instructions, Addition Instruction, Subtraction Instruction, Multiplication Instruction, Division Instruction, Other Word-Level Math Instructions, File Arithmetic Operations.

Module-5

Sequencer and Shift Register Instructions: Mechanical Sequencers, Sequencer Instructions, Sequencer Programs, Bit Shift Registers, Word Shift Operations.
Process Control, Network Systems, and SCADA: Types of Processes, Structure of Control Systems, On/Off Control, PID Control, Motion Control, Data Communications, Supervisory Control and Data Acquisition (SCADA).

Course outcomes: At the end of the course the student will be able to:

- Discuss history of PLC and describe the hardware components of PLC: I/O modules, CPU, memory devices, other support devices, operating modes and PLC programming.
- Describe field devices Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-In Circuits, and Latching Relays commonly used with I/O module.
- Analyze PLC timer and counter ladder logic programs and describe the operation of different program control instructions
- Discuss the execution of data transfer instructions, data compare instructions and the basic operation of PLC closed-loop control system.
- Describe the operation of mechanical sequencers, bit and word shift registers, processes and structure of control systems and communication between the processes.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Programmable Logic Controllers	Frank D Petruzella	McGraw Hill,	4th Edition, 2011
Reference Books				
1	Programmable Logic Controllers an Engineer's Guide	E A Parr	Newnes	3rd Edition, 2013
2	Introduction Programmable Logic Controllers	Gary Dunning	Cengage	3rd Edition, 2006

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

RENEWABLE ENERGY RESOURCES (OPEN ELECTIVE)

Course Code	18EE653	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- To discuss causes of energy scarcity and its solution, energy resources and availability of renewable energy.
- To explain sun – earth geometric relationship, Earth – Sun Angles and their Relationships.
- To discuss about solar energy reaching the Earth's surface and solar thermal energy applications.
- To discuss types of solar collectors, their configurations and their applications.
- To explain the components of a solar cell system, equivalent circuit of a solar cell, its characteristics and applications.
- To discus benefits of hydrogen energy, production of hydrogen energy, storage its advantages and disadvantages.
- To discuss wind turbines, wind resources, site selection for wind turbine.
- To discuss geothermal systems, their classification and geothermal based electric power generation
- To discuss waste recovery management systems, advantages and disadvantages.
- To discuss biomass production, types of biomass gasifiers, properties of producer gas.
- To discuss biogas, its composition, production, benefits.
- To discuss tidal energy resources, energy availability, power generation.
- To explain motion in the sea wave, power associated with sea wave and energy availability and the devices for harnessing wave energy.

Module-1

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

Energy from Sun: Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Applications.

Module-2

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

Solar Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Efficiency of Solar Cells, Photovoltaic panels (series and parallel arrays).

Module-3

Hydrogen Energy: Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy.

Wind Energy: Windmills, Wind Turbines, Wind Resources, Wind Turbine Site Selection.

Geothermal Energy: Geothermal Systems, Classifications, Geothermal Resource Utilization, Resource Exploration, Geothermal Based Electric Power Generation, Associated Problems, environmental Effects.

Solid waste and Agricultural Refuse: Waste is Wealth, Key Issues, Waste Recovery Management Scheme, Advantages and Disadvantages of Waste Recycling, Sources and Types of Waste, Recycling of Plastics.

Module-4

Biomass Energy: Biomass Production, Energy Plantation, Biomass Gasification, Theory of Gasification, Gasifier and Their Classifications, Chemistry of Reaction Process in Gasification, Updraft, Downdraft and Cross-draft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier, Gasifier Biomass Feed Characteristics, Applications of Biomass Gasifier, Cooling and Cleaning of Gasifiers.

Biogas Energy: Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas, Factors Affecting the Selection of a Particular Model of a Biogas Plant, Biogas Plant Feeds and their Characteristics.

Tidal Energy: Introduction, Tidal Energy Resource, Tidal Energy Availability, Tidal Power Generation in India, Leading Country in Tidal Power Plant Installation, Energy Availability in Tides, Tidal Power Basin, Turbines for Tidal Power, Advantages and Disadvantages of Tidal Power, Problems Faced in Exploiting Tidal Energy.

Module-5

Sea Wave Energy: Introduction, Motion in the sea Waves, Power Associated with Sea Waves, Wave Energy Availability, Devices for Harnessing Wave Energy, Advantages and Disadvantages of Wave Power.

Ocean Thermal Energy: Introduction, Principles of Ocean Thermal Energy Conversion (OTEC), Ocean Thermal Energy Conversion plants, Basic Rankine Cycle and its Working, Closed Cycle, Open Cycle and Hybrid Cycle, Carnot Cycle, Application of OTEC in Addition to Produce Electricity, Advantages, Disadvantages and Benefits of OTEC.

Course outcomes:

At the end of the course the student will be able to:

- Discuss causes of energy scarcity and its solution, energy resources and availability of renewable energy.
- Outline energy from sun, energy reaching the Earth's surface and solar thermal energy applications.
- Discuss types of solar collectors, their configurations, solar cell system, its characteristics and their applications.
- Explain generation of energy from hydrogen, wind, geothermal system, solid waste and agriculture refuse.
- Discuss production of energy from biomass, biogas.
- Summarize tidal energy resources, sea wave energy and ocean thermal energy.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Nonconventional Energy Resources	Shobh Nath Singh	Pearson	1st Edition, 2015
Reference Books				
1	Nonconventional Energy Resources	B.H. Khan	McGraw Hill	3rd Edition
2	Renewable Energy; Power for a sustainable Future	Godfrey Boyle	Oxford	3rd Edition, 2012
3	Renewable Energy Sources: Their Impact on global Warming and Pollution	Tasneem Abbasi S.A. Abbasi	PHI	1st Edition, 2011

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VI

INTRODUCTION TO DATA ANALYTICS (OPEN ELECTIVE)

Course Code	18EE654	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To explain introductory concepts, a brief methodological description and some descriptive statistics of data
- To explain multivariate descriptive statistics methods of data analytics, methods used in the data preparation phase of the CRISP-DM methodology, concerning data quality issues, converting data to different scales or scale types and reducing data dimensionality.
- To explain methods involving clustering, frequent pattern mining, which aims to capture the most frequent patterns.
- To explain cheat sheet and project on descriptive analytics and generalization, performance measures for regression and the bias–variance trade-off.
- To explain the binary classification problem, performance measures for classification, methods based on probabilities and distance measures and more advanced and state-of-the-art methods of prediction of data.

Module-1

Introductory: Introduction to Data, Big Data and Data Science, Big Data Architectures, Small Data, What is Data? A Short Taxonomy of Data Analytics, Examples of Data Use,A Project on Data Analytics.
Descriptive Statistics: Scale Types, Descriptive Univariate Analysis, Descriptive Bivariate Analysis.

Module-2

Multivariate Analysis: Multivariate Frequencies, Multivariate Data Visualization, Multivariate Statistics, Infographics and Word Clouds.
Data Quality and Preprocessing: Data Quality, Converting to a Different Scale Type, Converting to a Different Scale, Data Transformation, Dimensionality Reduction.

Module-3

Clustering: Distance Measures, Clustering Validation, Clustering Techniques.
Frequent Pattern Mining: Frequent Itemsets, Association Rules, Behind Support and Confidence, Other Types of Pattern.

Module-4

Cheat Sheet and Project on Descriptive Analytics: Cheat Sheet of Descriptive Analytics, Project on Descriptive Analytics.
Regression: Predictive Performance Estimation, Finding the Parameters of the Model, Technique and Model Selection.

Module-5

Classification: Binary Classification, Predictive Performance Measures for Classification,
Distance-based Learning Algorithms, Probabilistic Classification Algorithms.

Course Outcomes: At the end of the course the student will be able to:

- Define data, its architecture and examples of data use.
- Explain methods of descriptive analytics of data.
- Explain methods for multivariate analysis, data preparation and data transformation and reducing.
- Explain techniques for clustering the data and pattern mining
- Explain the methods of predictive analytics, performance measures for regression and algorithms for regression.
- Explain performance measures for classification of data and methods of prediction.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	A General Introduction to Data Analytics	João Mendes et al	Wiley	2019

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII

SOLAR AND WIND ENERGY (Professional Elective)

Course Code	**18EE731**	CIE Marks	40
Number of Lecture Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To discuss the importance of energy in human life, relationship among economy and environment with energy use.
- To discuss the increasing role of renewable energy, energy management, energy audit, energy efficiency, energy intensity.
- To discuss energy consumption status in India, energy saving potential and energy conservation efforts in India.
- To explain the concept of energy storage and the principles of energy storage devices.
- To discuss the characteristics and distribution of solar radiation, measurement of components of solar radiation and analysis of collected solar radiation data.
- To explain availability of solar radiation at a location and the effect of tilting the surface of collector with respect to horizontal surface.
- To describe the process of harnessing solar energy in the form of heat and working of solar collectors.
- To discuss applications of solar energy including heating and cooling.
- To discuss the operation of solar cell and the environmental effects on electrical characteristics of solar cell
- To discuss sizing and design of typical solar PV systems and their applications.
- To discuss basic Principles of Wind Energy Conversion and to compute the power available in the wind.
- To discuss forces on the Blades, Wind Energy Conversion, collection of Wind Data, energy estimation and site selection.
- To discuss classification of WEC Systems, its advantages and disadvantages of WECS, and Types of Wind Machines (Wind Energy Collectors).
- To evaluate the performance of Wind-machines, Generating Systems. ■

Module-1

Fundamentals of Energy Science and Technology: Introduction, Energy, Economy and Social Development, Classification of Energy Sources, Importance of Non -conventional Energy Sources, Salient features of Non-conventional Energy Sources, World Energy Status, Energy Status in India. **Energy Conservation and Efficiency:** Introduction, Important Terms and Definitions, Important Aspects of Energy Conservation, Global Efforts, Achievements and Future Planning, Energy Conservation/Efficiency Scenario in India, Energy Audit, Energy Conservation Opportunities.

Energy Storage: Introduction, Necessity of Energy Storage, Specifications of Energy Storage Devices. **Solar Energy-Basic Concepts:** Introduction, The Sun as Source of Energy, The Earth, Sun, Earth Radiation Spectrum, Extraterrestrial and Terrestrial Radiations, Spectral Power Distribution of Solar Radiation, Depletion of Solar Radiation. ■

Module-2

Solar Energy-Basic Concepts (continued): Measurement of Solar Radiation, Solar Radiation Data, Solar Time, Solar Radiation Geometry, Solar Day Length, Extraterrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface.

Solar Thermal Systems: Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating and Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers. ■

Module-3

Solar Photovoltaic Systems: Introduction, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell Technologies, Solar Cell, Module, and Array Construction, Maximizing the Solar PV Output and Load Matching. Maximum Power Point Tracker. Balance of System Components, Solar PV Systems, Solar PV Applications.

Module-4

Wind Energy: Introduction, Basic Principles of Wind Energy Conversion, History of Wind Energy, Wind Energy Scenario – World and India. The Nature of the Wind, The Power in the Wind, Forces on the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations **Wind energy systems:** Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis

Module-5

Basic Components of a Wind Energy Conversion(WEC) System: Classification of WEC systems, Advantages and Disadvantages of WECS, Types of Wind Machines (Wind Energy Collectors), Analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems, Energy Storage, Applications of Wind Energy, Environmental Aspects.

Course Outcomes:

At the end of the course the student will be able to:

- Discuss the importance of the role of renewable energy, the concept of energy storage and the principles of energy storage devices.
- Discuss the concept of solar radiation data and solar PV system fabrication, operation of solar cell, sizing and design of PV system.
- Describe the process of harnessing solar energy and its applications in heating and cooling.
- Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection.
- Discuss the performance of Wind-machines, energy storage, applications of Wind Energy and environmental aspects.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of three sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook

1	Non-Conventional Energy Resources	B. H. Khan	McGraw Hill	2nd Edition 2017
2	Non-Conventional Sources of Energy	Rai G. D.	Khanna Publishers	4th Edition, 2009

Reference Books

1	Non-Conventional Energy Resources	ShobhNath Singh	Pearson	1st Edition, 2015
2	Solar Energy – Principles of Thermal Collections and Storage	S.P. Sukhatme J.K.Nayak	McGraw Hill	3rd Edition, 2008
3	Wind Turbine Technology	Ahmad Hemami	Cengage	1st Edition, 2012

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

MICRO- AND NANO-SCALE SENSORS AND TRANSDUCERS (PROFESSIONAL ELECTIVE)

Course Code	18EE732	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To explain measurement of pressure using sensors, based nanotechnology, their structure, theory of operation.
- To explain structure, theory of operation of sensors based on nanotechnology for Motion, acceleration, measurement, gas and smoke detection.
- To explain sensors based on nanotechnology for the measurement of atmospheric moisture and moisture inside the electronic components.
- To explain Optoelectronic and Photonic Sensors used in optical microphones, fingerprint readers, and highly sensitive seismic sensors.
- To explain the structure, operation of Biological Sensors, Chemical Sensors, and the so-called "Lab-on-a-Chip" sensors used in multipurpose biological and chemical analysis devices and Electric, Magnetic, and RF/Microwave, Integrated Sensor/Actuator Units and Special Purpose Sensors driven by nanotechnology.

Module-1

Pressure Sensors: Capacitive Pressure Sensors, Inductive Pressure Sensors, Ultrahigh Sensitivity Pressure Sensors.

Module-2

Motion and Acceleration Sensors: Ultrahigh Sensitivity, Wide Dynamic Range Sensors, Other Motion and Acceleration Microsensors.
Gas and Smoke Sensors: A CO Gas Sensor Based on Nanotechnology, Smoke Detectors.

Module-3

Moisture Sensors: Structure, Theory, Main Experimental Results, Auxiliary Experimental Results.
Optoelectronic and Photonic Sensors: Optoelectronic Microphone, Other Optoelectronic and Photonic Micro Sensors.

Module-4

Biological, Chemical, and "Lab on a Chip" Sensors: Lab on a Chip Sensors, Other Biochemical Micro- and Nano-Sensors.
Electric, Magnetic, and RF/Microwave Sensors: Magnetic Field Sensors, Other Important Electromagnetic/RF Micro- and Nano-Sensors.

Module-5

Integrated Sensor/Actuator Units and Special Purpose Sensors: Aircraft Icing Detectors, Other Special Purpose Small-Scale Devices.

Course Outcomes: At the end of the course the student will be able to:

- Understand the differences between the sensor and transducer technology based on nanotechnology and nanofabrication and the classical sensor technologies
- Make an informed selection of a sensor or transducer for a particular application;
- Become knowledgeable about the technologies that are available commercially at the present time.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				

1	Micro- and Nano-Scale Sensors and Transducers	Ezzat G. Bakhoum	CRC Press	2015

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

INTEGRATION OF DISTRIBUTION GENERATION (PROFESSIONAL ELECTIVE)

Course Code	18EE733	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To explain power generation by alternate energy source like wind power and solar power.
- To explain selection of size of units and location for wind and solar systems.
- Discuss the effects of integration of distributed generation on the performance the system.
- To provide practical and useful information about grid integration of distributed generation.

Module-1

Distributed Generation: Introduction, status, Properties of wind power, Power Distribution as a function of wind speed, Solar Power: Status, Properties, Space requirements, Photovoltaic's, Seasonal variation in production capacity, Combined Heat-and-Power: Status, Options for space Heating, Hydropower: Properties of Large Hydro, Properties of small Hydro, Variation with time, Tidal Power, Wave Power, Geothermal Power, Thermal Power Plant.

Module-2

Distributed Generation(continued): Interface with the Grid. Power System Performance: Impact of Distributed Generation on the Power System, Aims of the Power System, Hosting Capacity Approach, Power Quality, Voltage Quality and Design of Distributed Generation, Hosting Capacity Approach for Events, Increasing the Hosting Capacity. Overloading and Losses: Impact of Distributed Generation, Overloading: Radial Distribution Networks, Active Power Flow Only, Active and Reactive Power Flow Overloading: Redundancy and Meshed Operation, Redundancy in Distribution Networks, Meshed Operation, Losses.

Module-3

Over loading and Losses (continued): Increasing the Hosting Capacity: Increasing the Loadability Building New Connections, Inter trip Schemes, Advanced protection Schemes, Energy Management Systems. Power Electronics approach, Demand Control, Prioritizing Renewable Energy, Dynamic Loadability.

Voltage Magnitude Variations: Impact of Distributed Generation, Voltage Marginand Hosting Capacity: Voltage Control in Distribution Systems, Voltage Rise Owing to Distributed Generation, Hosting Capacity, Estimating hosting capacity without Measurements, Sharing hosting capacity. Design of Distribution Feeders: Basic Design Rules, Terminology, An Individual Generator Along a Medium-Voltage Feeder, Low voltage feeders, Series and Shunt Compensation, A Numerical Approach to Voltage Variations: Example for Two-stage Boosting, General Expressions for Two-Stage Boosting Tap Changers with Line- Drop Compensation: Transformer with One Single Feeder, Adding a Generator. Probabilistic Methods for Design of Distribution Feeders: Need for Probabilistic Methods, The System Studied, Generation with Constant Production, Adding Wind Power.

Module-4

Voltage Magnitude Variations (continued): Statistical Approach to Hosting Capacity, Increasing the Hosting Capacity: New or Stronger Feeders, Alternative Methods for Voltage Control Accurate Measurement of the Voltage Magnitude Variations, Allowing Higher Overvoltage's Overvoltage Protection, Over Voltage Curtailment Compensating the generators voltage variations, Distributed generation with voltage control, Coordinated voltage control.

Power Quality Disturbances: Impact of Distributed Generation, Fast Voltage Fluctuations: Fast Fluctuations in Wind Power, Fast Fluctuations in Solar Power, Rapid Voltage Changes, Very Short Variations. Voltage Unbalance: Weaker Transmission System, Stronger Distribution System, Large Single-Phase Generators, Stronger Distribution Grid Voltage Unbalance.

Module-5

Power Quality Disturbances(continued): Low-Frequency Harmonics: Wind Power: Induction Generators, Generators with Power Electronics Interfaces, Synchronous Generators, Measurement Example, Harmonic Resonances, Weaker Transmission Grid, Stronger Distribution Grid. High-Frequency Distortion: Emission by Individual Generators, Grouping Below and Above 2 kHz, Limits Below and Above 2 kHz,Voltage Dips:

Synchronous Machines Balanced Dips and Unbalanced Dips, Induction generators and unbalanced dips. Increasing the Hosting Capacity: Strengthening the Grid, Emission Limits for Generator Units, Emission Limits for Other Customers, Higher Disturbance Levels, Passive Harmonic Filters, Power Electronics Converters, Reducing the Number of Dips, Broadband and High-Frequency Distortion.

Course Outcomes: At the end of the course the student will be able to:

- Explain energy generation by wind power and solar power.
- Discuss the variation in production capacity at different time scales, the size of individual units, and the flexibility in choosing locations with respect to wind and solar systems.
- Explain the performance of the system when distributed generation is integrated to the system.
- Discuss effects of the integration of DG: the increased risk of overload, increased losses, increased risk of overvoltages and increased levels of power quality disturbances.
- Discuss effects of the integration of DG: incorrect operation of the protection.
- Discuss the impact the integration of DG on power system stability and operation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Integration of Distributed Generation in the Power System	Math Bollen	Wiley	2011

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
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SEMESTER – VII

ADVANCED CONTROL SYSTEMS (PROFESSIONAL ELECTIVE)

Course Code	18EE734	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- To introduce state variable approach for linear time invariant systems in both the continuous and discrete time systems.
- To explain development of state models for linear continuous – time and discrete – time systems.
- To explain application of vector and matrix algebra to find the solution of state equations for linear continuous – time and discrete – time systems.
- To define controllability and observability of a system and testing techniques for controllability and observability of a given system.
- To explain design techniques of pole assignment and state observer using state feedback.
- To explain about inherent and intentional nonlinearities that can occur in control system and developing the describing function for the nonlinearities.
- To explain stability analysis of nonlinear systems using describing function analysis.
- To explain the analysis of nonlinear systems using Lyapunov function and design of Lyapunov function for stable systems.

Module-1

State Variable Analysis and Design: Introduction, Concept of State, State Variables and State Model, State Models for Linear Continuous–Time Systems, State Variables and Linear Discrete– Time Systems.

Module-2

State Variable Analysis and Design (continued): Diagonalization, Solution of State Equations, Concepts of Controllability and Observability.

Module-3

Pole Placement Design and State Observers: Introduction, Stability Improvements by State Feedback, Necessary and Sufficient Conditions for Arbitrary Pole Placement, State Regulator Design, Design of State Observer, Compensator Design by the Separation Principle.

Module-4

Non-linear systems Analysis: Introduction, Common Nonlinear System Behaviours, Common Nonlinearities in Control Systems, Fundamentals, Describing Functions of Common Nonlinearities, Stability Analysis by Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane.

Module-5

Non-linear systems Analysis (continued): Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems.

Course Outcomes: At the end of the course the student will be able to:

- Discuss state variable approach for linear time invariant systems in both the continuous and discrete time systems.
- Develop of state models for linear continuous–time and discrete–time systems.
- Apply vector and matrix algebra to find the solution of state equations for linear continuous–time and discrete–time systems.
- Define controllability and observability of a system and test for controllability and observability of a given system.
- Design pole assignment and state observer using state feedback.

- Develop the describing function for the nonlinearity present to assess the stability of the system.
- Develop Lyapunov function for the stability analysis of nonlinear systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Control Systems Engineering (For the Modules1 and 2)	I.J. Nagarathand M.Gopal	NewAge	5th Edition,2007
2	Digital Control and State Variable Methods: Conventional and Intelligent Control Systems	M.Gopal	McGrawHill	3rd Edition,2008
3	Modern Control Theory	R. V. Parvatikar	Prism Books Pvt. Ltd.	1st Edition,2014

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SEMESTER – VII

REACTIVE POWER CONTROL IN ELECTRIC POWER SYSTEMS (PROFESSIONAL ELECTIVE)

Course Code	18EE735	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To identify the necessity of reactive power compensation.
- To describe load compensation.
- To select various types of reactive power compensation in transmission systems.
- To characterize distribution side and utility side reactive power management.
- To contrast reactive power coordination system.

Module-1

Theory of Load Compensation: Requirement for compensation, Objectives in load compensation, Ideal compensator, Acceptance standards for quality of supply, Specifications of aload compensator, Power factor correction and voltage regulations in single phase system: Power Factor and its Correction, Voltage regulation. T1. Classical load balancing problem: open loop balancing. R1.

Module-2

Theory of Steady State Reactive Power in Uncompensated & Compensated Transmission Line : Fundamental requirement in AC power transmission, advantages& disadvantages of different types of compensating equipment for transmission systems, fundamental transmission line equation, surge impedance and natural loading, voltage and current profiles of uncompensated line on open circuit, uncompensated line under load, effect of line length, load power and power factor on voltage and reactive power.

Compensated Transmission Line: Types of compensation, passive and active compensators, Uniformly distributed fixed compensation: Effect of distributed compensation on voltage control and effect of distributed compensation on line charging reactive power. T1

Module-3

Basics of Capacitors, Reactive Power of Capacitors, Arrangements and Reactive Power of Capacitors, Capacitors Connected in Parallel: Capacitors Connected in Series, Star and Delta Connection of Power Capacitors, Design of MV Capacitors . T2

Passive shunt compensation: Control of open circuit voltage with shunt reactors, required reactance values of shunt reactors. T1

Series compensation: Objectives and practical limitations, Symmetrical line with mid-point series capacitor and shunt reactor, Power transfer characteristics and maximum transmissible power Fundamental concepts of compensation by sectioning. T1

Module-4

Static Compensation: Practical applications of static compensators in electrical power systems, main types of compensators, principle of operation of Thyristor Controlled Reactor (TCR), Thyristor Controlled Transformer, TCR with shunt capacitors and Thyristor Switched Capacitor (TSC), principle of operation of saturated reactor compensators.

Series Capacitors: compensation factor, protective gear, Varistor protective gear, Resonance effects with series capacitors

Synchronous Condenser: Condenser operation, Power system Voltage control, Emergency reactivepower supply, HVDC application.

Comparison of basic types of compensator. T1

Module-5

Harmonics: Effect of harmonics on electrical equipment, resonance, shunt capacitors and filters, telephone interferences.

Reactive Power Co-ordination: Reactive power management, transmission benefits, reactive power dispatch & equipment impact.T1

Reactive Power Planning: Economic justification for reactive power planning, methods followed by the electricity boards in India, zonal reactive power requirements EHV & MV, low tension capacitors, placement in distribution, line capacitors. T3

Course Outcomes: At the end of the course the student will be able to:

- Distinguish the importance of load compensation in symmetrical as well as unsymmetrical loads.
- Observe various compensation methods in transmission lines.
- Distinguish demand side reactive power management & user side reactive power management.
- Construct model for reactive power coordination and effects of harmonics on electrical equipment.
- Discuss the Reactive Power Planning for the electricity boards.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Reactive power control in electric power systems	T. J. E. Miller	John Wiley & Sons	2009
2	Reactive Power Compensation : A Practical Guide	Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just.	John Wiley	2012
3	Reactive Power Management	D. Tagare	TMH	1st Edition, 2004
Reference Books				
1	Power Quality Enhancement Using Custom Power Devices	Arindam Ghosh, Gerard Ledwich	Kluwer International	2002
2	Power System Voltage Stability	Carson. W. Taylor	McGraw-Hill	1993

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

INDUSTRIAL DRIVES AND APPLICATION (PROFESSIONAL ELECTIVE)

Course Code	18EE741	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To define electric drive, its parts, advantages and explain choice of electric drive.
- To explain dynamics and modes of operation of electric drives.
- To explain selection of motor power ratings and control of DC motor using rectifiers.
- To analyze the performance of induction motor drives under different conditions.
- To explain the control of induction motor, synchronous motor and stepper motor drives.
- To discuss typical applications electrical drives in the industry.

Module-1

Electrical Drives: Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and ac Drives.

Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability, Load Equalization.

Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives.

Module-2

Direct Current Motor Drives: Controlled Rectifier Fed DC Drives, Single Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Single Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Multi-quadrant Operation of DC Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of DC Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited DC Motor, Chopper Control of Series Motor.

Module-3

Induction Motor Drives: Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.

Module-4

Induction Motor Drives (continued): Voltage Source Inverter (VSI) Control, Cycloconverter Control, Closed Loop Speed Control and Converter Rating for VSI and Cycloconverter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.

Synchronous Motor Drives: Operation from fixed frequency supply-starting, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors.

Module-5

Synchronous Motor Drives (continued): Self-controlled synchronous motor drive employing load commutated thyristor inverter, Starting Large Synchronous Machines, Permanent Magnet ac (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, Brushless DC Motor Drives.

Stepper Motor Drives: Variable Reluctance, Permanent Magnet, Important Features of Stepper Motors, Torque Versus Stepping rate Characteristics, Drive Circuits for Stepper Motor.

Industrial Drives: Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools.

Course Outcomes: At the end of the course the student will be able to:

- Explain the advantages, choice and control of electric drive
- Explain the dynamics, generating and motoring modes of operation of electric drives
- Explain the selection of motor power rating to suit industry requirements
- Analyze the performance & control of DC motor drives using controlled rectifiers
- Analyze the performance & control of converter fed Induction motor, synchronous motor & stepper motor drives.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Fundamentals of Electrical Drives	Gopal K. Dubey	Narosa Publishing	2nd Edition, 2001
2	Electrical Drives: Concepts and Applications (Refer to chapter 07 for Industrial Drives	VedumSubrahmanyam	McGraw Hill	2nd Edition, 2011
Reference Books				
1	Electric Drives	N.K De,P.K. Sen	PHI Learning	1st Edition, 2009

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SEMESTER – VII

UTILIZATION OF ELECTRICAL POWER (PROFESSIONAL ELECTIVE)

Course Code	18EE742	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To discuss electric heating, air-conditioning and electric welding.
- To explain laws of electrolysis, extraction and refining of metals and electro deposition.
- To explain the terminology of illumination, laws of illumination, construction and working of electric lamps.
- To explain design of interior and exterior lighting systems- illumination levels for various purposes light fittings- factory lighting- flood lighting-street lighting
- To discuss systems of electric traction, speed time curves and mechanics of train movement.
- To discuss motors used for electric traction and their control.
- To discuss braking of electric motors, traction systems and power supply and other traction systems.
- Give awareness of technology of electric and hybrid electric vehicles.

Module-1

Heating and welding: Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Air – Conditioning, Electric Welding, Modern Welding Techniques.

Electrolytic Electro – Metallurgical Process: Ionization, Faraday's Laws of Electrolysis, Definitions, Extraction of Metals, Refining of Metals, Electro Deposition.

Module-2

Illumination: Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting.

Module-3

Electric Traction Speed - Time Curves and Mechanics of Train Movement: Introduction, Systems of Traction, Systems of electric Traction, Speed - Time Curves for Train Movement, Mechanics of Train Movement, Train Resistance, Adhesive Weight, Coefficient of Adhesion.

Motors for Electric traction: Introduction, Series and Shunt Motors for Traction Services, Two Similar Motors (Series Type) are used to drive a Motor Car, Tractive Effort and Horse Power, AC Series Motor, Three Phase Induction Motor.

Control of motors: Control of DC Motors, Tapped Field Control or Control by Field Weakening, Multiple Unit Control, Control of Single Phase Motors, Control of Three Phase Motors.

Module-4

Braking: Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro – Mechanical Drum

Brakes.

Electric Traction Systems and Power Supply: System of Electric Traction, AC Electrification, Transmission Lines to Sub - Stations, Sub – Stations, Feeding and Distribution System of AC Traction Feeding and Distribution System for DC Tramways, Electrolysis by Currents through Earth, Negative Booster, System of Current Collection, Trolley Wires.

Trams, Trolley Buses and Diesel – Electric Traction: Tramways, The Trolley – Bus, Diesel Electric Traction.

Module-5

Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption.

Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.

Course Outcomes: At the end of the course the student will be able to:

- Discuss different methods of electric heating & welding.
- Discuss the laws of electrolysis, extraction, refining of metals and electro deposition process.
- Discuss the laws of illumination, different types of lamps, lighting schemes and design of lighting systems.
- Analyze systems of electric traction, speed time curves and mechanics of train movement.
- Explain the motors used for electric traction, their control & braking and power supply system used for electric traction.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	A Text Book on Power System Engineering	A. Chakrabarti et al	DhanpatRai and Co	2nd Edition, 2010
2	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals Theory, and Design (Chapters 04 and 05 for module 5)	Mehrdad Ehsani et al	CRC Press	1st Edition, 2005
Reference Books				
1	Utilization, Generation and Conservation of Electrical Energy	Sunil S Rao Khanna	Publishers	1st Edition, 2011
2	Utilization of Electric Power and Electric Traction	G.C. Garg	Khanna Publishers	9th Edition, 2014

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SEMESTER – VII

AI TECHNIQUES FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES (PROFESSIONAL ELECTIVE)

Course Code	18EE743	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To explain IoT Based Battery Management System (BMS) and types of batteries for Hybrid Electric Vehicles (HEV)
- To explain advantages of AI, the use of brushless DC motor and its control in electric vehicle.
- To explain the optimization techniques and control strategies for active magnetic bearing (AMB) system for electric vehicle.
- To explain the modelling and analysis of power converters and hybrid energy storage system foe electric vehicles.

Module-1

IoT-Based Battery Management System for Hybrid Electric Vehicle: IoT Based Battery Management System (BMS) for Hybrid Electric Vehicles (HEV) : Introduction, Battery configuration, Types of batteries for HEV and Electric Vehicles (EV), Functional Blocks of Battery Management Systems, IoT based BMS.

Module-2

Brushless Direct Current Motor Drive Using Artificial Intelligence for Optimum Operation of the Electric Vehicle: Basics of Artificial Intelligence, Advantages of Artificial Intelligence in EV, Brushless DC Motor, Mathematical Representation Brushless DC Motor, Closed-Loop Model of BLDC Motor Drive, PID Controller, Fuzzy Control, Auto-Tuning Type Fuzzy PID Controller, Genetic Algorithm, Artificial Neural Network-Based Controller, BLDC Motor Speed Controller with ANN Based PID Controller, Analysis of Different Speed Controllers.

Module-3

Optimization Techniques Used in Active Magnetic Bearing System for Electric Vehicles : Basic Components of an Active Magnetic Bearing (AMB), Active Magnetic Bearing in Electric Vehicles System, Control Strategies for AMB in EVs.

Module-4

Small-Signal Modeling Analysis of Three-Phase Power Converters for EV Applications : Introduction, Overall System Modeling, Mathematical Modeling and Analysis of Small Signal Modeling.

Module-5

Energy Management of Hybrid Energy Storage System (HESS) in PHEV With Various Driving Mode: Introduction, Problem Description, and Formulation, Modeling of HESS and its Analysis.

Course Outcomes: At the end of the course the student will be able to:

- Discuss IoT Based Battery Management System and type of batteries for EV and HEV.
- Explain AI Based BLDC drive for optimum operation of EV.
- Explain Active Magnetic Bearing system for EVs.
- Model and analyse three phase converters for EV applications.
- Model and analyse Energy Management of HESS in PHEV.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and
Textbook				

1	Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles	Chitra A, P. Sanjeevikumar, and S. Himavathi	Wiley	2020

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SEMESTER – VII

SMART GRID (PROFESSIONAL ELECTIVE)

Course Code	18EE744	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the basic concept of smart grid, attributes of Smart Grid
- To describe the over view of the perfect power system configuration
- To know about DC power delivering systems ,data centres and information technology loads
- To educate the importance of Technology Alternatives in smart Grid
- To understand the Dynamic energy systems in Smart Grid
- To describe the overview of Demand side planning and evaluation.

Module-1

Introduction: Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, attributes of the smart grid.

Smart Grid to Evolve a Perfect Power System: Introduction, overview of the perfect power system configurations, device level power system, building integrated power systems, distributed power systems, fully integrated power system.

Module-2

DC Distribution and Smart Grid: AC Vs. DC sources, benefits of and drives of DC power delivery systems, powering equipment and appliances with DC, data centers and information technology loads, potential future work and research

Intelligrid Architecture for the Smart Grid: Introduction, launching intelligrid, intelligrid today, smart grid vision based on the intelligrid architecture.

Module-3

Dynamic Energy Systems Concept: Smart energy efficient end use devices, smart distributed energy resources, advanced whole building control systems, integrated communications architecture, energy management, role of technology in demand response, current limitations to dynamic energy management, distributed energy resources, overview of a dynamic energy management, key characteristics of smart devices, key characteristics of advanced whole building control systems, key characteristics of dynamic energy management system.

Module-4

Efficient Electric End Use Technology Alternatives: Existing technologies ,lighting, space conditioning, indoor air quality, domestic water heating, hyper efficient appliances, ductless residential heat pumps and air conditioners, variable refrigerant flow air conditioning, heat pump water heating, hyper efficient residential appliances, data center energy efficiency, LED street and area lighting, industrial motors and drives, equipment retrofit and replacement, process heating, cogeneration, thermal energy storage, industrial energy management programs, manufacturing process, electro -technologies, residential, commercial and industrial sectors.

Module-5

Demand side planning: Introduction, Selecting Alternatives, Issues Critical to the Demand-side Issues Critical to the Demand-side, The Utility Planning Process, Demand-side Activities, Alternatives that Are Most Beneficial.

Demand-Side Evaluation: Levels of Analysis. General Information Requirements, Context, Transferability, Data Requirement, Cost/Benefit Analysis, Program Interaction.

Course Outcomes: At the end of the course the student will be able to:

- Explain the concept of Smart grid enables the ElectricNet and need of smart grid.
- Outline the benefits and drivers of DC Power delivery system.
- Summarize the Intelligrid Architecture for the smart grid.
- Explain the Efficient Electric End-use Technology Alternatives.
- Discuss Demand side planning and Evaluation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	The Smart Grid, Enabling Energy Efficiency and Demand Side Response	Clark W Gellings	CRC Press,	3rd Edition, 2013
Reference Books				
1	Smart Grid :Technology and Applications	Janaka Ekanayake et al	Wiley	2012
2	Smart Grid :Fundamentals of Design and Analysis	James Momoh	Wiley IEEE Press	2012

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

ARTIFICIAL NEURAL NETWORK WITH APPLICATIONS TO POWER SYSTEMS
(PROFESSIONAL ELECTIVE)

Course Code	18EE745	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the fundamental concepts and models of Artificial Neural Systems.
- To understand neural processing, learning and adaptation, Neural Network learning rules.
- Ability to analyze multilayer feed forward networks.
- Ability to develop various ancillary techniques applied to power system and control of power systems.

Module-1

Fundamental Concepts and Models of Artificial Neural Systems

Biological Neurons and their artificial models – Biological Neuron, McCulloch-Pitts Neuron Model, Neuron modeling for Artificial neural systems. Models for Artificial Neural Networks – Feed forward Network, Feedback network.

Module-2

Neural Processing, Learning and Adaptation, Neural Network Learning Rules

Neural Processing. Learning and Adaptation – Learning as Approximation or Equilibria Encoding, Supervised and Unsupervised Learning. Neural Network Learning Rules – Hebbian Learning Rule, Perceptron Learning Rule, Delta Learning Rule, Widrow-Hoff Learning Rule, Correlation Learning Rule, Winner-Take-All Learning Rule, Outstar Learning Rule, Summary of Learning Rules.

Module-3

Multilayer Feedforward Networks

Feedforward Recall and Error Back-Propagation Training – Feedforward Recall, Error Back-Propagation Training, Training Errors and Multilayer Feedforward Networks as Universal Approximators (Excluding Examples). Learning Factors – Initial Weights, Cumulative Weight Adjustment versus Incremental Updating, Steepness of the Activation Function, Learning Constant, Momentum Method, Network Architectures Versus Data Representation, Necessary Number of Hidden Neurons.

Module-4

Neural Network and its Ancillary Techniques as Applied to Power Systems

Introduction, Learning versus Memorization, Determining the Best Net Size, Network Saturation, Feature Extraction, Inversion of Neural Networks, Alternative Training Method: Genetic Based Neural Network, Fuzzified Neural Network.

Module-5

Control of Power Systems

Introduction, Background, Neural Network Architectures for modeling and control, Supervised Neural Network Structures, Diagonal Recurrent Neural Network based Control System, Convergence and Stability.

Course Outcomes: At the end of the course the student will be able to:

- Develop Neural Network and apply elementary information processing tasks that neural network can solve.
- Develop Neural Network and apply powerful, useful learning techniques.
- Develop and Analyze multilayer feed forward network for mapping provided through the first network layer and error back propagation algorithm.
- Analyze and apply algorithmic type problems to tackle problems for which algorithms are not available.
- Develop and Analyze supervised/unsupervised, learning modes of Neural Network for different applications.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Introduction to Artificial Neural Systems.	Jacek M. Zurada	JAICO Publishing House	2006
2	Artificial Neural Networks with Applications to Power Systems	Edited by – Mohamed El – Sharkawi and Dagmar Niebur	IEEE, Inc.	1996

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SEMESTER – VII

CARBON CAPTURE AND STORAGE (OPEN ELECTIVE)

Course Code	18EE751	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction: The carbon cycle, Mitigating growth of the atmospheric carbon inventory, The process of technology innovation.

Overview of carbon capture and storage: Carbon capture, Carbon storage.

Power generation fundamentals: Physical and chemical fundamentals, Fossil-fueled power plant, Combined cycle power generation, Future developments in power-generation technology.

Module-2

Carbon capture from power generation: Introduction, Precombustion capture, Postcombustion capture, Oxyfuel combustion capture, Chemical looping capture systems, Capture-ready and retrofit power plant, Approaches to zero-emission power generation.

Carbon capture from industrial processes: Cement production, Steel production, Oil refining, Natural gas processing.

Absorption capture systems: Chemical and physical fundamentals, Absorption applications in post-combustion capture, Absorption technology RD and D status.

Module-3

Adsorption capture systems: Physical and chemical fundamentals, Adsorption process applications, Adsorption technology RD and D status.

Membrane separation systems: Physical and chemical fundamentals, Membrane configuration and preparation and module construction, Membrane technology RD and D status, Membrane applications in pre-combustion capture, Membrane and molecular sieve applications in oxyfuel combustion, Membrane applications in postcombustion CO_2 separation, Membrane applications in natural gas processing.

Module-4

Cryogenic and distillation systems: Physical Fundamentals, Distillation column configuration and operation, Cryogenic oxygen production for oxyfuel combustion, Ryan–Holmes process for CO_2 –CH_4 separation, RDand D in cryogenic and distillation technologies.

Mineral carbonation: Physical and chemical fundamentals, Current state of technology development, Demonstration and deployment outlook.

Geological storage: Introduction, Geological and engineering fundamentals, Enhanced oil recovery, Saline aquifer storage, Other geological storage options.

Module-5

Ocean storage: Introduction, Physical, chemical, and biological fundamentals, Direct CO_2 injection, Chemical sequestration, Biological sequestration.

Storage in terrestrial ecosystems: Introduction, Biological and chemical fundamentals, Terrestrial carbon storage options, Full GHG accounting for terrestrial storage, Current R&D focus in terrestrial storage.

Other sequestration and use options: Enhanced industrial usage, Algal biofuel production.

Carbon dioxide transportation: Pipeline transportation, Marine transportation.

Course outcomes:

At the end of the course the student will be able to:

- Discuss the impacts of climate change and the measures that can be taken to reduce emissions.
- Discuss carbon capture and carbon storage.
- Explain the fundamentals of power generation.
- Explain methods of carbon capture from power generation and industrial processes.
- Explain different carbon storage methods: storage in coal seams, depleted gas reservoirs and saline formations.

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook

1. Carbon Capture and Storage, Stephen A. Rackley, Elsevier, 2010.

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

ELECTRIC VEHICLES (OPEN ELECTIVE)

Course Code	18EE752	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- To Understand the fundamental laws and vehicle mechanics.
- To Understand working of Electric Vehicles and recent trends.
- Ability to analyze different power converter topology used for electric vehicle application.
- Ability to develop the electric propulsion unit and its control for application of electric vehicles.

Module-1

Vehicle Mechanics: Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power, Force-Velocity Characteristics, Maximum Gradability, Velocity and Acceleration, Constant FTR, Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Nonconstant FTR, General Acceleration, Propulsion System Design.

Module-2

Electric and Hybrid Electric Vehicles: Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains.

Module-3

Energy storage for EV and HEV: Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modelling of PEMFC, Supercapacitors.

Module-4

Electric Propulsion:
EV consideration, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives.

Module-5

Design of Electric and Hybrid Electric Vehicles: Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design.

Course outcomes:
At the end of the course the student will be able to:

- Explain the roadway fundamentals, laws of motion, vehicle mechanics and propulsion system design.
- Explain the working of electric vehicles and hybrid electric vehicles in recent trends.
- Model batteries, Fuel cells, PEMFC and super capacitors.
- Analyze DC and AC drive topologies used for electric vehicle application.
- Develop the electric propulsion unit and its control for application of electric vehicles.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Husain	CRC Press	2003
2	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design	M. Ehsani, Y. Gao, S.Gay and Ali Emadi	CRC Press	2005
Reference Books				
1	Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles	Sheldon S. Williamson	Springer	2013
2	Modern Electric Vehicle Technology	C.C. Chan and K.T. Chau	OXFORD University	2001
	Hybrid Electric Vehicles Principles And Applications With Practical Perspectives	Chris Mi, M. Abul Masrur, David Wenzhong Gao	Wiley Publication	2011

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
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SEMESTER – VII

DISASTERS MANAGEMENT (OPEN ELECTIVE)

Course Code	18EE753	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To explain disaster management, its planning, occurrence of cyclones and their hazard potential
- To explain the role of IMD, cyclone prediction and cyclone warning system in India
- To explain the role of different institutions, defence and other services in natural disaster management.
- To explain the role of Central Water Commission in river water sharing, Draught, its assessment and draught management plan
- To explain reasons for the occurrence of earth quake, Tsunamis and thunderstorms.

Module-1

Disaster Management Plan (DMP): - General.
Cyclones and their Hazard Potential: Classification of Low-Pressure Systems, Statistics of Cyclonic Storms Over Indian Seas, Movement of Cyclqnes in Indian Seas, Storm Surges.

Module-2

India Meteorological Department and Cyclone Warnings in India: Hazard Potential of Cyclonic Storms, Cyclone Prediction and Dissemination of Warnings, Dissemination of Cyclone Warnings, Cydone Warnings through INSAT, Port Warnings with Day and Night hoisting Sib'Tlals.
Cyclones Disaster Management – Plan: Hazard Potentials Associated with Cyclones, Vulnerability Reduction, Early Warning.

Module-3

Action Plan for Cyclone Disaster Management.
Role of Different Institutions in Natural Disaster Management: Role of Zilla Parishad, Role of PRA Groups in Disaster Management, Role of NGOs, Self Help Groups in Disaster Management, Role of Red Cross in Disaster Management.
The Role of Defence and other Services in Disaster Management: Role of Air Force in Disaster Management, Role of Medical and Health Department in Cyclone disaster management, National Disaster Response Force (NDRF), Role of Remote Sensing in Disaster Management, Role of Broadcast, Educational Media in disaster management.

Module-4

4Floods: Water Wealth of India, Definition of Flood, Role of Central Water Commission, Monsoons, Flood Warning Signals and Precautionary Actions, Water Purification Technologies in Flood Affected Areas.
Drought: Meteorological Drought, Breaks in the Monsoon, Drought Management Plan, Drought Years for Different Met Subdivision of India, Drought Assesment, Drought Parameters, Role of Banking, Insurance, Microfinance in drought mitigation, Drought Monitoring, Drought Research Unit (IMD), Rainwater harvesting.

Module-5

Earth quakes: Interior Structure of the Earth, Plate Techtonics, Seismcity of India, Earthquake Forecast and disaster management, Tsunamis, Landslides and Avalanches, Volcanoes.
Hazards associated with Convective Clouds: Climatology of World Thunderstorms, Lightning, Some Effects of Electric Shock, Favours and Frownings of Thunderstorms, Hailstorms, Tornadoes, Waterspouts, Dust-Devils, Nowcasting, Summer Thunderstorms over India, Cold Waves and Heat Waves - Cold Waves in India, Heat Waves in India.

Course Outcomes: At the end of the course the student will be able to:

- Discuss disaster management plan, cyclones and their hazard potential
- Understand the role of IMD and cyclone prediction and cyclone warning system in India
- Understand the role of different institutions defence and other services in natural disaster management.
- Understand the role of Central Water Commission in river water sharing, Draught, its assessment and draught management plan

- Understand occurrence of earth quake, Tsunamis and thunderstorms.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and
Textbook				
1	Earth and Atmospheric Disasters Management Natural and Man-made	Navale Pandharinath, C. K. Rajan,	BS Publications	2009

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

ELECTRICAL ENERGY CONSERVATION AND AUDITING (OPEN ELECTIVE)

Course Code	18EE754	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- Understand the current energy scenario and importance of energy conservation.
- Understand the methods of improving energy efficiency in different electrical systems.
- Realize energy auditing.
- Explain about various pillars of electricity market design.
- To explain the scope of demand side management, its concept and implementation issues and strategies.

Module-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.

Module-2

Energy Efficiency in Electrical Systems: Electricity billing, Electrical load management and maximum demand Control, Maximum demand controllers; Power factor improvement, Automatic power factor controllers, efficient operation of transformers, energy efficient motors, Soft starters, Variable speed drives; Performance evaluation of fans and pumps, Flow control strategies and energy conservation opportunities in fans and pumps, Electronic ballast, Energy efficient lighting and measures of energy efficiency in lighting system.

Module-3

Energy auditing: Introduction, Elements of energy audits, different types of audit, energy use profiles, measurements in energy audits, presentation of energy audit results.

Module-4

Electricity vis-à-vis Other Commodities: Distinguishing features of electricity as a commodity, Four pillars of market design: Imbalance, Scheduling and Dispatch, Congestion Management, Ancillary Services. Framework of Indian power sector and introduction to the availability based tariff (ABT).

Module-5

Energy Audit Applied to Buildings: Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings.
Demand side Management: Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM.

Course outcomes:

At the end of the course the student will be able to:

- Analyze about energy scenario nationwide and worldwide , also outline Energy Conservation Act and its features.
- Discuss load management techniques and energy efficiency.
- Understand the need of energy audit and energy audit methodology.
- Understand various pillars of electricity market design.
- Conduct energy audit of electrical systems and buildings.
- Show an understanding of demand side management and energy conservation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher
Textbookss			
1	Energy Management Handbook	W.C. Turner	John Wiley and Sons
2	Energy Efficient Electric Motors and Applications	H.E. Jordan	Plenum Pub. Corp
3	Energy Management	W. R. Murphy, G. Mckay	Butterworths
Reference Books			
1	Energy Science Principles, Technologies and Impact	J. Andrews, N. Jelley	Oxford University Press.
2	Market operations in power systems: Forecasting, Scheduling, and Risk Management	Shahedepour M.,Yamin H., Zuyi Li.	John Wiely & Sons, New York
3	Energy Conservation	Diwan, P.	Pentagon Press (2008)

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CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VIII

FACTS AND HVDC TRANSMISSION (PROFESSIONAL ELECTIVE)

Course Code	18EE821	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

• To discuss transmission interconnections, flow of Power in an AC System, limits of the loading capability, dynamic stability considerations of a transmission interconnection and controllable parameters.

• To explain the basic concepts, definitions of flexible ac transmission systems and benefits from FACTS technology.

• To describe shunt controllers, Static Var Compensator and Static Compensator for injecting reactive power in the transmission system in enhancing the controllability and power transfer capability.

• To describe series Controllers Thyristor-Controlled Series Capacitor (TCSC) and the Static Synchronous Series Compensator (SSSC) for control of the transmission line current.

• To explain advantages of HVDC power transmission, overview and organization of HVDC system.

• To describe the basic components of a converter, the methods for compensating the reactive power demanded by the converter.

• Explain converter control for HVDC systems, commutation failure, control functions.

Module-1

FACTS Concept and General System Considerations: Transmission Interconnections, Flow of Power in an AC System, What Limits the Loading Capability? Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Basic Types of FACTS Controllers, Brief Description and Definitions of FACTS Controllers, Checklist of Possible Benefits from FACTS Technology, In Perspective: HVDC or FACTS.

Module-2

Static Shunt Compensators: Objectives of Shunt Compensation - Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, Improvement of Transient Stability. Methods of Controllable Var Generation –Thyristor controlled Reactor (TCR) and Thyristor Switched Reactor (TSR), Thyristor Switched Capacitor (TSC).Operation of Single Phase TSC – TSR. Switching Converter Type Var Generators, Basic Operating Principles, Basic Control Approaches.

Static VAR Compensators: SVC and STATCOM, the Regulation Slope. Comparison between STATCOM and SVC, V –I and V –Q Characteristics, Transient stability**,** Response Time.

Module-3

Static Series Compensators: Objectives of Series Compensation, Concept of Series Capacitive Compensation, Voltage Stability, Improvement of Transient Stability. GTO Thyristor-Controlled Series Capacitor, Thyristor-Switched Series Capacitor, Thyristor-Controlled Series Capacitor, The Static synchronous Series Compensator, Transmitted Power Versus Transmission Angle Characteristic.

Module-4

Development of HVDC Technology: Introduction, Advantages of HVDC Systems, HVDC System Costs, Overview and Organization of HVDC Systems, HVDC Characteristics and Economic Aspects.

Power Conversion: 3-Phase Converter, 3-Phase Full Bridge Converter, 12-Pulse Converter.

Module-5

Control of HVDC Converter and System: Converter Control for an HVDC System, Commutation Failure, HVDC Control and Design, HVDC Control Functions, Reactive Power and Voltage Stability.

Course Outcomes: At the end of the course the student will be able to:

• Discuss transmission interconnections, flow of Power in an AC System, limits of the loading capability, dynamic stability considerations of a transmission interconnection and controllable parameters.

• Explain the basic concepts, definitions of flexible ac transmission systems and benefits from FACTS technology.

• Describe shunt controllers, Static Var Compensator and Static Compensator for injecting reactive power in the transmission system in enhancing the controllability and power transfer capability.
• Describe series Controllers Thyristor-Controlled Series Capacitor (TCSC) and the Static Synchronous Series Compensator (SSSC) for control of the transmission line current.
• Explain advantages of HVDC power transmission, overview and organization of HVDC system.
• Describe the basic components of a converter, the methods for compensating the reactive power demanded by the converter.
• Explain converter control for HVDC systems, commutation failure, control.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems	Narain G Hingorani, Laszlo Gyugyi	Wiley	1st Edition, 2000
2	HVDC Transmission: Power Conversion Applications in Power Systems	Chan-Ki Kim et al	Wiley	1st Edition, 2009
Reference Books				
1	Thyristor Based FACTS Controllers for Electrical Transmission Systems	R. Mohan Mathur, Rajiv K. Varma	Wiley	1st Edition, 2002

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VIII

ELECTRICAL ESTIMATION AND COSTING (PROFESSIONAL ELECTIVE)

Course Code	18EE822	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To discuss the purpose of estimation and costing.
- To discuss market survey, estimates, purchase enquiries, tenders, comparative statement and payment of bills and Indian electricity act and some of the rules.
- To discuss distribution of energy in a building, wiring and methods of wiring, cables used in internal wiring, wiring accessories, fittings and fuses.
- To discuss design of lighting points and its number, total load, sub-circuits, size of conductor.
- To discuss different types of service mains and estimation of power circuits.
- To discuss estimation of overhead transmission and distribution system and its components.
- To discuss main components of a substation, their graphical representation and preparation of single line diagram of a substation.

Module-1

Principles of Estimation: Introduction to Estimation and Costing, Electrical Schedule, Catalogues, Market Survey and Source Selection, Recording of Estimates, Determination of Required Quantity of Material, Labour Conditions, Determination of Cost Material and Labour, Contingencies, Overhead Charges, Profit, Purchase System, Purchase Enquiry and Selection of Appropriate Purchase Mode, Comparative Statement, Purchase Orders, Payment Of Bills, Tender Form, General Idea about IE Rule, Indian Electricity(IE) Act and IE Rules -29,30,45,46,47,50,51,54,55,77 and79.

Module-2

Wiring: Introduction, Distribution of energy in a Building, PVC Casing and Capping, Conduit Wiring, Desirabilities of Wiring. Types of cables used in Internal Wiring, Multi Strand Cables, Voltage Grading and Specification of Cables.

Wiring (continued): Main Switch and Distribution Board, Conduits and its accessories and Fittings. Lighting Accessories and Fittings, Types of Fuses, Size of Fuse, Fuse Units, Earthing Conductor.

Internal Wiring: General rules for wiring, Design of Lighting Points (Refer to Seventh Chapter of the Text Book), Number of Points, Determination of Total Load, Number of Sub –Circuits, Ratings Main Switch and Distribution Board and Size of Conductor. Current Density, Layout.

Module-3

Service Mains: Introduction, Types, Estimation of Underground and Overhead Service Connections. Design and Estimation of Power Circuits: Introduction, Important Considerations Regarding Motor Installation Wiring, Input Power, Input Current to Motors, Rating of Cables, Rating of Fuse, Size of Condit, Distribution Board Main Switch and Starter.

Module-4

Estimation of Overhead Transmission and Distribution Lines: (Review of Line Supports, Conductor Materials, Size of Conductor for Overhead Transmission Line, Types of Insulators) [No Question Shall be Set From the Review Portion].

Cross Arms, Pole Brackets and Clamps, Guys and Stays, Conductors Configuration Spacing and Clearances, Span Lengths, Lightning Arrestors, Phase Plates, Danger Plates, Anti Climbing Devices, Bird Guards, Beads of Jumpers, Muffs, Points to be Considered at the Time of Erection of Overhead Lines, Erection of Supports, Setting of Stays, Fixing of Cross Arms, Fixing of Insulators, Conductor Erection. Repairing and Jointing of Conductors, Dead End Clamps, Positioning of Conductors and Attachment to Insulator s, Jumpers, Tee-Offs, Earthing of Transmission Lines, Guarding of Overhead Lines, Clearances of Conductor From Ground, Spacing Between Conductors, Important Specifications.

Module-5

Estimation of Substations: Main Electrical connection, Graphical Symbols for Various Types of Apparatus and Circuit Elements on Substation main Connection Diagram, Single Line Diagram of Typical Substations, Equipment for Substation, Substation Auxiliaries Supply, Substation Earthing.

Course Outcomes: At the end of the course the student will be able to:

- Discuss wiring methods, cables used, design of lighting points and sub-circuits, internal wiring, wiring accessories and fittings, fuses and types.
- Discuss estimation of service mains and power circuits.
- Discuss estimation of overhead transmission and distribution system its components.
- Discuss types of substation, main components and estimation of substation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	A Course in Electrical Installation Estimating and Costing	J. B. Gupta	Katson Books	9th Edition, 2012

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SEMESTER – VIII

BIG DATA ANALYTICS IN POWER SYSTEMS (PROFESSIONAL ELECTIVE)

Course Code	18EE823	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course objectives:

- To define big data and to explain big data application and analytics to power systems.
- To explain the role of big data in smart grid communications and optimization of big data in electric power systems.
- To explain security methods for the infrastructure communication and data mining methods for theft detection in power systems.
- To explain the application of unit commitment method in the control of smart grid.
- To explain protection algorithm for transformer based on data pattern recognition.

Module-1

Introduction: Big Data, Future Power Systems.
Big Data Application and Analytics in a Large - Scale Power System: Introduction, General Applications of Big Data, Algorithms for Processing Big Data, Application of Big Data in Power Systems.

Module-2

Role of Big Data in Smart Grid Communications: Introduction, The Grid Modernization, The Grid Interconnection with the Internet of Things, Data Traffic Pattern in a Smart Grid Environment, The Massive Flow of Information in a Smart Scenario ,The Volume of Generated Data in a Smart Distribution System: A Case of Study.
Big Data Optimization in Electric Power Systems: Introduction, Background, Scientometric Analysis of Big Data, Big Data and Power Systems, Optimization Techniques Used in the Big Data Analysis.

Module-3

Security Methods for Critical Infrastructure Communications: Introduction, Effects of Successful Communication System Threats, General Communication System Operations, Industrial Control Networks and Operations, High-Level Communication System Threats, Cyber Threats and Security. **Data - Mining Methods for Electricity Theft Detection:** Introduction, Transmission and Distribution System Losses, Electricity Theft Methods, Data Mining and Electricity Theft, Issues and Directions in Electricity Theft-Related Data-Mining Research.

Module-4

Unit Commitment Control of Smart Grids: Introduction, Renewable Energy Resources, The Unit Commitment Problem, A Multi-agent Architecture, Illustrative Example.

Module-5

Transformer Differential Protection Algorithm Based on Data Pattern Recognition: Big Data and Power System Protection, Methods for Differential Protection Blocking, Principal Component Analysis, Curvilinear Component Analysis (CCA), PCA Applied to Discriminate Between Inrush and Fault, Currents in Transformers, Application of the CCA as a Base for a Differential Protection System Under Study, Results.

Course outcomes:

At the end of the course the student will be able to:

- Discuss role of big data and machine-learning methods applicable to power systems and in particular to Smart Grid communications.
- Discuss optimization methods which are suitable for big data models in power systems.
- Discuss various cyber security issues, electricity theft detection and mitigation that exist in IoT-enabled future power systems.
- Discuss renewable energy planning concerns associated with planned future power systems that have high renewable penetration.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Big Data Analytics in Future Power Systems	Ahmed F. Zobaa and Trevor J. Bihl	CRC Press	2019.

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SEMESTER – VIII

POWER SYSTEM PLANNING (PROFESSIONAL ELECTIVE)

Course Code	18EE824	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

• To discuss primary components of power system planning namely load furcating, evaluation of energy resources, provisions of electricity Act and Energy Conservation Act.
• To explain planning methodology for optimum power system expansion, various types of generation, transmission and distribution.
• To explain forecasting of anticipated future load requirements of both demand and energy by deterministic and statistical techniques using forecasting tools.
• To discuss methods to mobilize resources to meet the investment requirement for the power sector.
• To perform economic appraisal to allocate the resources efficiently and take proper investment decisions
• To discuss expansion of power generation and planning for system energy in the country
• To discuss evaluation of operating states of transmission system, their associated contingencies and determination of the stability of the system for worst case conditions
• To discuss principles of distribution planning, supply rules, network development and the system studies.
• To discuss reliability criteria for generation, transmission, distribution and reliability evaluation and analysis.
• To discuss grid reliability, voltage disturbances and their remedies.
• To discuss planning and implementation of electric –utility activities designed to influence consumer uses of electricity.
• To discuss market principles and the norms framed by CERC for online trading and exchange in the interstate power market.

Module-1

Power System: Planning Principles, Planning Process, Project Planning, Power Development, National and Regional Planning, Enterprise Resources Planning, Planning Tools, Power Planning Organisation, Scenario Planning.
Electricity Forecasting: Load Requirement, System Load, Electricity Forecasting, Forecasting Techniques, Forecasting Modelling, Spatial – Load Forecasting, Peak Load - Forecast, Reactive – Load Forecast, Unloading of a System.

Module-2

Power-System Economics: Financial Planning, Techno – Economic Viability, Private Participation, Financial Analysis, Economic Analysis, Transmission, Rural Electrification Investment, Total System Analysis, Credit - Risk Assessment.
Generation Expansion: Generation Capacity and Energy, Generation Mix, Clean Coal Technologies Renovation and Modernisation of Power Plants.

Module-3

Transmission Planning: Transmission Planning Criteria, Right – of – Way, Network Studies, High – Voltage Transmission, HVDC Transmission, Conductors, Sub – Stations, Power Grid, Reactive Power Planning, Energy Storage.

Module-4

Distribution: Distribution Deregulation, Planning Principles, Electricity – Supply Rules, Criteria and Standards, Sub – Transmission, Basic Network, Low Voltage Direct Current Electricity, Upgradation of Existing Lines and Sub – Stations, Network Development, System Studies, Urban Distribution, Rural Electrification.
Reliability and Quality: Reliability Models, System Reliability, Reliability and Quality Planning, Functional Zones, Generation Reliability Planning Criteria, Transmission Reliability Criteria, Distribution Reliability, Reliability Evaluation, Grid Reliability, Quality of Supply.

Module-5

Demand-Side Planning: Demand Response, Demand – Response Programmes, Demand– Response Technologies, Energy Efficiency, Energy - Economical Products, Efficient – Energy Users, Supply – Side Efficiency, Energy Audit.

Electricity Market: Market Principles, Power Pool, Independent System Operator, Distribution SystemOperator, Power Markets, Market Rules, Bidding, Trading, Settlement System, Merchant Power, Differential Electricity, Congestion Management, Ancillary Services, Hedging, Smart Power Market.

Course Outcomes: At the end of the course the student will be able to:

- Discuss primary components of power system planning, planning methodology for optimum power system expansion and load forecasting.
- Understand economic appraisal to allocate the resources efficiently and appreciate the investment decisions
- Discuss expansion of power generation and planning for system energy in the country, evaluation of operating states of transmission system, their associated contingencies and the stability of the system.
- Discuss principles of distribution planning, supply rules, network development and the system studies
- Discuss reliability criteria for generation, transmission, distribution and reliability evaluation and analysis, grid reliability, voltage disturbances and their remedies
- Discuss planning and implementation of electric –utility activities, market principles and the norms framed.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Electric Power Planning	A. S. Pabla	McGraw Hill	2nd Edition, 2016

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VIII

ELECTRICAL POWER QUALITY (PROFESSIONAL ELECTIVE)

Course Code	18EE825	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Review definitions and standards of common power quality phenomena.
- Understand power quality monitoring and classification techniques.
- Investigate different power quality phenomena causes and effects.
- Understand different techniques for power quality problems mitigation.
- Understand the various power quality phenomenon, their origin and monitoring and mitigation methods.
- Understand the effects of various power quality phenomenon in various equipment.

Module-1

Introduction: Power quality-voltage quality, power quality evaluation procedures term and definitions: general classes of power quality problems, transients, long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, power quality terms.

Module-2

Voltage sags and interruptions: Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, motor starting sags.
Transient over voltages: Sources of transient over voltages, principles of over voltages protection, utility capacitor switching transients.

Module-3

Transient over voltages: Fundamentals of harmonics: Harmonic distortion, voltage versus transients, harmonic indexes, harmonic sources from commercial loads, harmonic sources from Industrial loads, effects of harmonic distortion, intra harmonics.

Module-4

Applied harmonics: Harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters, standards of harmonics.
Power Quality Benchmark: Introduction, benchmark process, power quality contract.

Module-5

Power quality benchmark: power quality state estimation, including power quality in distribution planning.
Distributed generation and quality: DG technologies, interface to utility system, power quality issues, interconnection standards.

Course Outcomes: At the end of the course the student will be able to:

- Define Power quality; evaluate power quality procedures and standards.
- Estimate voltage sag performance; explain principles of protection and Sources of transient over voltages.
- Identify various sources of harmonics, explain effects of harmonic distortion.
- Evaluate harmonic distortion, control harmonic distortion.
- Estimate power quality in distribution planning. Identify power quality issues in utility system.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				

1	Electric Power Quality	Dugan, Roger C	McGraw-Hill	2003
Reference Books				
1	Electric Power Quality	G.T.Heydt	Stars in a circle publications	1991
2	Understanding power quality problems voltage sags and interruptions	Math H. J. Bollen.	IEEE Press	2000
3	Power quality in power systems and electrical machines	Ewald F Fuchs, Mohammad, A.S., Masoum	Academic Press, Elsevier	2009

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