`

HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABUS

Under CBCS

(Applicable for Students admitted from Academic Year 2020-2021)

M. Tech. Electrical and Electronics Engineering

Specialization in Smart Grid and Electric Vehicle

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SCHOOL OF ELECTRICAL SCIENCES

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE
VISION AND MISSION

Motto

To Make Every Man A Success And No Man A Failure

Vision

To be an International Institute of Excellence, providing a conducive environment for education with a strong emphasis on innovation, quality, research and strategic partnership blended with values and commitment to society.

Mission

- To create an ecosystem for learning and world class research.
- To nurture a sense of creativity and innovation.
- To instill highest ethical standards and values with a sense of professionalism.
- To take up activities for the development of Society.
- To develop national and international collaboration and strategic partnership with industry and institutes of excellence.
- To enable graduates to become future leaders and innovators.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VISION AND MISSION

Vision of the Department

To educate the students in the recent developments of emerging fields in Electrical and Electronics Engineering, to encourage research activities, innovative techniques and to develop managerial abilities so as to make them excel globally with ethical values.

Mission of the Department

M1: To empower students with state-of-art Knowledge and Technological skills in Electrical and Electronics Engineering.
M2: To upgrade curriculum continuously to meet the Emerging Industrial Requirement.
M3: To mould students for Research, Innovation and Entrepreneurship.
M4: To inculcate Managerial and Professional capabilities with Ethics and Human values.

M. Tech. Electrical and Electronics Engineering
Specialization in Smart Grid and Electric Vehicle

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The program is expected to enable the students to

PEO I Design and develop innovative products and services in the field of Smartgrid and Electric Vehicles.

PEO II keeps abreast with the latest technology and toolset.

PEO III Communicate effectively to propagate ideas and promote teamwork

PEO IV Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

PROGRAM OUTCOMES (PO)

At the end of this program, graduates will be able to

1. **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions
3**. Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions.
4. **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.
5. **Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
6. **Individual and teamwork:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
7. **Communication skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and

listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

8.**Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

9. **Impact of engineering on society and the environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. **Ethics and equity:** An ability to apply professional ethics, accountability, and equity.

11. **Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

12. **Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: An ability to design and develop environmental friendly electrical Vehicle

PSO2: To introduce application of smart grid and electric vehicle for conversion, control and automation.

PSO3: Apply appropriate techniques and modern Engineering hardware and software tools in electric vehicle to engage in life- long learning and to successfully adapt in multi-disciplinary environments.

PSO4: Understand the impact of Professional Engineering solutions in societal and environmental context, commit to professional ethics and communicate effectively.

M. Tech. Electrical and Electronics Engineering Specialization in Smart Grid and Electric Vehicle									
(65 CREDIT)									
SEMESTER - I									
1	PC	MAA3705	Advanced Mathematics for Electrical Engineers	3	0	0	3	1	3
2	PC	EEC1701	Smart Grid	3	0	0	3	1	3
3	PC	EEC1702	Renewable Power Generation Technologies	3	0	0	3	1	3
4	DE		Department Elective – I	3	0	0	3	1	3
5	DE		Department Elective- II	3	0	0	3	1	3
6	PC	ZZZ3715	Research Methodology & IPR	2	0	0	2	1	2
PRACTICAL									
7	PC	EEC3791	Modelling and simulation of smart grid lab	0	0	3	2	0	3
8	PC	EEC3780	Mini Project	0	0	3	2	2	3
Total				**19**	**0**	**3**	**21**	**6**	**20**

SEMESTER - II									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
THEORY									
1	PC	EEC1705	Intelligence and Communication in smart grid	3	0	0	3	1	3
2	PC	EEC1703	Electric Vehicle Technology	3	0	0	3	1	3
3	PC	EEC1704	Power Electronic Converters for Smart grids and Electric Vehicles	3	0	0	3	1	3
4	DE		Department Elective - III	3	0	0	3	1	3

5	NE		Non Department Elective	3	0	0	3	1	3
PRACTICAL									
6	PC	EEC3792	Modelling and Simulation of Electric Vehicle lab	0	0	3	2	0	3
7	PC	EEA3780	Seminar	0	0	3	2	2	3
Total				**15**	**0**	**6**	**19**	**5**	**27**

SEMESTER - III									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
PRACTICAL									
1	DE		Department Elective - IV	3	0	0	3	1	3
2	PC	EEC3797	Internship	0	0	3	2		3
3	PC	EEC3798	Project Phase –I	0	0	16	8		16
Total				**3**	**0**	**19**	**13**	**1**	**19**

SEMESTER - IV									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	EEC3799	Project Phase –II	0	0	24	12		24
Total				**0**	**0**	**24**	**12**	**0**	**24**

LIST OF DEPARTMENTAL ELECTIVES - SEMESTER WISE									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
Department Elective - I									
1	DE	EEC3721	Modelling and Simulation of EHV	3	0	0	3	1	3
2	DE	EEC3722	Electric Vehicle In Smart Grid	3	0	0	3	1	3
3	DE	EEC3723	Testing and Certification Of Electric and Hybrid Vehicles	3	0	0	3	1	3
4	DE	EEC3724	In-Vehicle Networking	3	0	0	3	1	3
Department Elective - II									
5	DE	EEC3725	EV Batteries & Charging System	3	0	0	3	1	3
6	DE	EEC3726	Micro Electro Mechanical Systems	3	0	0	3	1	3
7	DE	EEC3727	Electric and Hybrid Vehicles	3	0	0	3	1	3
8	DE	EEC3728	Electric Motors & Control	3	0	0	3	1	3
Department Elective - III									
9	DE	EEC3729	Computer Aided Design of Electric Machines	3	0	0	3	1	3
10	DE	EEC3730	Optimization Techniques	3	0	0	3	1	3
11	DE	EEC3731	Vehicular networks in communication	3	0	0	3	1	3
12	DE	EEC3732	Energy Storage Systems and Control	3	0	0	3	1	3
Department Elective - IV									
1	DE	EEC3733	Power System Planning And Reliability	3	0	0	3	1	3

2	DE	EEC3734	Power System Automation	3	0	0	3	1	3
3	DE	EEC3735	Energy Auditing And Management	3	0	0	3	1	3
4	DE	EEC3736	Distributed Generation And Micro-Grids	3	0	0	3	1	3

LIST OF NON DEPARTMENTAL ELECTIVES OFFERED BY ELECTRICAL DEPARTMENT WITH GROUPING - SEMESTER WISE									
SEM	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
2	NE	EEC3741	Photovoltaic and fuel cell systems	3	0	0	3	1	3
2	NE	EEC3742	Wind and hydro energy systems	3	0	0	3	1	3
2	NE	EEC3743	Biomass energy systems	3	0	0	3	1	3
2	NE	EEC3744	Artificial Neural Network & Fuzzy Logic Applications	3	0	0	3	1	3

SEMESTER – I

COURSE TITLE	ADVANCED MATHEMATICS FOR ELECTRICAL ENGINEERS			CREDITS	3
Course Code	MAA3705	Course Category	PC	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

CO	COURSE OUTCOMES	PO
1	Getting idea about basic fundamentals of probability	1,2,4
2	Getting idea about optimization techniques	1,2,5
3	Getting idea about differential calculus	1,2,12

Prerequisites : Nil

MODULE 1 – ADVANCED MATRIX THEORY (9L)

Matrix norms – Jordan canonical form – Generalized eigenvectors – Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm

MODULE 2 – NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS (9L)

Solutions of large systems of equations using Gauss Elimination method; principle behind sparsity and optimal ordering; relevance of the solution technique for engineering applications.

MODULE 3 – NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (9L)

Single and multi – step methods – explicit and implicit methods – advantages of implicit methods – solution of differential algebraic methods encountered in power engineering.

MODULE 4 – LINEAR PROGRAMMING (9L)

Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

MODULE 5 – DYNAMIC PROGRAMMING (9L)

Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

REFERENCE BOOKS

1	Lewis.D.W., “Matrix Theory”, Allied Publishers,Chennai 1995.
2	Bronson,R, “Matrix Operations”, Schaums outline Series ,McGraw Hill ,Newyork. 1989.
3	L.O.Chua, P.M.Lin, “Computer-Aided Analsis of Electronic Circuits”, Prentice Hall, Englewood Cliffs, New Jersey, 1978.
4	Taha, H.A., " Operations research - An Introduction ", Mac Millan publishing Co., (1982).
5	Gupta, P.K.and Hira, D.S., "Operations Research", S.Chand & Co., New Delhi,1999.

COURSE TITLE	SMART GRID			CREDITS	3
COURSE CODE	EEC1701	COURSE CATEGORY	DE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Get acquainted with different smart devices and smart meters	1,2,3,4,5,11
2	Describe how modern power distribution system functions	1,2,3,4,5,11
3	Identify suitable communication networks for Smart Grid applications	1,2,3,4,5,11

Prerequisites : Fundamentals of Power Distribution System, Transmission and Distribution, Power system Operation and Control

MODULE 1 – INTRODUCTION TO SMART GRID (9L)

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

MODULE 2 – ENERGY MANAGEMENT SYSTEM (9L)

Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

MODULE 3 – DISTRIBUTION MANAGEMENT SYSTEM (9L)

Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles

MODULE 4 – SMART METERS (9L)

Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

MODULE 5 – COMMUNICATION NETWORKS & IOT (9L)

Elements of communication and networking – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

LAB / MINI PROJECT/FIELD WORK

FIELD WORK

TEXT BOOKS

1 Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.

2	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012
REFERENCE BOOKS	
1	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015
2	Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014.

COURSE TITLE	**RENEWABLE POWER GENERATION TECHNOLOGIES**			**CREDITS**	**3**
COURSE CODE	**EEC1702**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell.	1,2,3,4,5,12
2	Design and analyze stand-alone and grid connected PV system.	1,2,3,4,5,12
3	Describe the dynamics of wind turbine and electrical generator	1,2,3,4,5,12
4	Select and design suitable configuration of the wind energy conversion system based on application.	1, 2,3,4,5,12
5	Suggest, design and analyze hybrid energy systems.	1,2,3,4,5,12

Prerequisites : Basic Electrical Engineering

MODULE 1 – SOLAR ENERGY (9L)

Definition, Energy available from Sun, Solar radiation data, solar energy conversion into heat, Flat plate and Concentrating collectors, Principle of natural and forced convection. power generation. PV Systems - Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking

MODULE 2 – WIND ENERGY (9L)

Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations power curve - power speed characteristics-choice of electrical generators

MODULE 3 – WIND TURBINE GENERATOR SYSTEMS (9L)

Fixed speed induction generator-performance analysis- semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator- permanent magnet alternator - performance analysis

MODULE 4 – NATURE OF GEOTHERMAL RESOURCES (9L)

Definition and classification of resources, Utilization for electricity generation and direct heating, Wellhead power generating units. Basic features: Atmospheric exhaust and condensing, Exhaust types of conventional steam turbines. Pyrolysis of Biomass to produce solid, liquid and gaseous

fuels. Biomass gasification, Constructional details of gasifier, Usage of biogas for chullas, various types of chullas for rural energy needs.	
MODULE 5 – HYBRID ENERGY SYSTEMS (9L)	
wind-diesel system, wind - PV system ,micro hydro-PV system ,biomass - PV-diesel system, geothermal-tidal and OTEC systems	
LAB / MINI PROJECT/FIELD WORK	
Mini Project: Prototype modelling of Renewable power Generation	
TEXT BOOKS	
1	Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers 2005
2	Ashok Desai V, *Non-Conventional Energy*, Wiley Eastern Ltd, 2003
3	Mittal K.M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, 2003.
4	Ramesh R, Kurnar K.U, Renewable Energy Technologies, Narosa Publishing House, New Delhi, reprint 2003.
REFERENCE BOOKS	
1	Chetan Singh Solanki, 'Solar Photovoltaics -Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., New Delhi, 2011
2	Van Overstraeton and Mertens R.P., 'Physics, Technology and use of Photovoltaics', Adam Hilger, Bristol,1996.
3	John F.Walker& Jenkins. N , 'Wind energy Technology', John Wiley and sons, Chichester, UK, 1997.
4	Freries LL ,'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990

COURSE TITLE	**RESEARCH METHODOLOGY & IPR**				**CREDITS**	**2**
COURSE CODE	**ZZZ3715**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**2-0-0-0**	
CIA	**50%**			**ESE**	**50%**	
LEARNING LEVEL	**BTL-5**					

CO	**COURSE OUTCOMES**	**PO**
1.	Understand research problem formulation.	1,2,3
2.	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.	1,2,3
3.	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	1,2,3,5
4.	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.	1,2,3,5
5.	Analyze research related information and to follow research ethics	1,2,3,12

Prerequisites: Nil

MODULE 1 – RESEARCH PROBLEM FORMULATION (9L)	
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	
MODULE 2 –RESEARCH PROPOSAL AND ETHICS (9L)	
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	
MODULE 3 - DATA ANALYSIS AND INTERPRETATION (9L)	
Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.	
MODULE 4 - NATURE OF INTELLECTUAL PROPERTY (9L)	
Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
MODULE 5 – PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR (9L)	
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	
REFERENCE BOOKS	
1	Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’,
2	Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3	Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
5	Mayall , “Industrial Design”, McGraw Hill, 1992.
6	Niebel , “Product Design”, McGraw Hill, 1974.
7	Asimov, “Introduction to Design”, Prentice Hall, 1962.
8	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
9	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
10	C.R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International publishers, Third Edition
11	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
12	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
13	Creswell, John W. Research design: Qualitative, quantitative, and mixed methods, approaches. Sage publications, 2013.

Course Title	Modelling and simulation of smart grid lab				2
Course Code	EEC3791	Course Category	PC	L-T-P-S	0-03-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Construct and simulate smart distribution system	1,3,4,5
2	Construct and simulate MPPT controller	1,3,4,5,12
3	Construct and simulate grid integration	1,3,4,5,12

Prerequisites: -: Basic Power Electronics

Practical: **(45)**

1. Micro Grid Operation in Smart Distribution System
2. Micro grid Integration of Hybrid PV/ Wind / Battery Management System Using Fuzzy Logic Controller
3. Design of Hybrid Electric Power System Utility.
4. Design of solar MPPT controller
5. Fuzzy logic control based MPPT for Wind Power System
6. ANFIS Based Grid integration of Photovoltaic Power System using multilevel inverter

COURSE TITLE	Intelligence and Communication in smart grid			CREDITS	3
COURSE CODE	EEC1705	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-4		

S.No	COURSE OUTCOMES	PO
1	To know about basics of communication in smart grid	1,2,3,4,5,6,11
2	To understand about advanced metering infrastructure protocols	1,2,3,4,5,6,11
3	To analyse about sensor communications	1,2,3,4,5,6,11
4	To analyse about big data	1,2,3,4,5,6,11
5	To know about intelligent sensing	1,2,3,4,5,6,11

Prerequisites : Basic Electrical Engineering	
MODULE I – Introduction	9
Need of intelligence and communication in Smart Grid, Case Study on Postmortem Analysis of Blackouts Drivers Toward the Smart Grid; NETWORK layered ARCHITECTURE, Protocols and standards for information exchange	
MODULE II – Protocols	9
Advanced Metering Infrastructure Protocols aiding AMI IEEE 802.15.4, 6LoWPAN, ROLL, and RPL, IEEE 802.11 255, Modbus, DNP3, IEC 61850, Ethernet, Power line carrier communication, CAN Bus, I2C, LIN Bus protocol, Modbus protocol structure; Profibus protocol stack, Profibus communication model, Bluetooth, ZigBee, IEEE 801.11-a,b,g,n, Z-Wave, Cellular networks, WiMAX	
MODULE III– Sensor Communications	9
Techniques for sensing: Phasor measurement units, Compressive sensing, Decentralized and cooperative sensing; Techniques for sensor communications: Machine-to-machine communications, Cooperative communications, Cognitive radio (CR); Medium access control, routing, and transport protocols for sensor data communications; Networked control systems- Time driven, Event driven feedback schemes.	
MODULE IV- Big data analysis	9
Substation Automation Architecture; Data Analytics: Big Data Collection, sampling and preprocessing; Smart Grid Data Analytics : Event Analytics, State Analytics, Customer Analytics, data analytics platform and Operational Analytics ; Big Data Architecture and Platforms ; Application of Big Data in Smart Grids	
MODULE V– Intelligent sensing	9
Intelligent Sensing : missing sensor restoration (MSR) , Monitoring and Identification : PMU for system Identification and state estimation, Power System Operation Support : Forecasting - time series analysis, regression analysis and other statistical methods; ANN short-term load forecaster, Physics-based numerical weather prediction (NWP) , Scheduling : deterministic optimization methods.	
REFERENCE BOOKS	
1	Stephen F. Bush, “Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid” ISBN: 978-1-119-97580-9 March 2014 Wiley-IEEE Press
2	Fadlullah, Zubair& Fouda, Mostafa& Kato, Nei& Takeuchi, Akira & Iwasaki, Noboru & Nozaki, Yousuke,2011
3	Toward Intelligent Machine-to-Machine Communications in Smart Grid. Communications Magazine, IEEE. 49. 60 - 65. 10.1109/MCOM.2011.5741147,2011
4	Kaveth Pahlavan. K. and Prashanth Krishnamurthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
5	Bart Baesens”Analytics in a Big data world” Wiley Publications,2004

COURSE TITLE	ELECTRIC VEHICLE TECHNOLOGY			CREDITS	3
COURSE CODE	EEC1703	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-5		

S.No	COURSE OUTCOMES	PO
1	To understand about basics of hybrid electric vehicle	1,2,3,4,5,6,11
2	To understand about drives and control.	1,2,3,4,5,6,11
3	Select battery, battery indication system for EV applications	1,2,3,4,5,6,11
4	Design battery charger for an EV	1,2,3,4,5,6,11

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – Introduction to Hybrid Electric Vehicle 9

Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving,

MODULE II – Electric Drives 9

Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor

MODULE III– Energy Storage 9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle,

MODULE IV- Energy Management System **9**

Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges,

MODULE V – Mobility and Connectors **9**

Connected Mobility and Autonomous Mobility- case study Emobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.

Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,

REFERENCE BOOKS

1	Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003
2	Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.
3	Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
4	Tariq Muneer and Irene IllescasGarcía, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017
5	Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013

COURSE TITLE	**Power Electronic Converters for Smart grids and Electric Vehicles**			**CREDITS**	**3**
COURSE CODE	**EEC1704**	**Course Category**	**PC**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-4**		

S.No	**COURSE OUTCOMES**	**PO**
1	Discuss about the different types of energy storage system.	1,2,3,4,5,6,11
2	Describe about the battery characteristic & parameters.	1,2,3,4,5,6,11
3	Analyse different types of batteries.	1,2,3,4,5,6,11
4	Apply the concepts of battery management system and design the battery pack.	1,2,3,4,5,6,11
5	Explain about the battery testing, disposal and recycling.	1,2,3,4,5,6,11

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – ENERGY STORAGE SYSTEM	9

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System
Suggested reading: Study of different types of batteries

MODULE II – BATTERY CHARACTERISTICS & PARAMETERS	9

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

MODULE III– BATTERY MODELLING	9

General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model, Simulation examples.	
MODULE IV– BATTERY PACK AND BATTERY MANAGEMENT SYSTEM	9
Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.	
MODULE V– BATTERY TESTING, DISPOSAL & RECYCLING	9
Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries , Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.	

REFERENCE BOOKS

1	Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
2	Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", Springer, 2018. (ISBN: 978-3-319-70571-2)
3	Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley& Sons Ltd., 2016.
4	Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.
5	G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"
6	T R Crompton, "Battery Reference Book-3 rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.
7	James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.
8	G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"

Course Title	**Modelling and Simulation of Electric Vehicle lab**				**2**
Course Code	**EEA3792**	**Course Category**	**PC**	**L-T-P-S**	**0-03-0**
CIA	**60%**		**ESE**	**40%**	

LEARNING LEVEL	BTL-4	
CO	**COURSE OUTCOMES**	**PO**
1	Simulation of GUI for small transformer	1,3,4,5
2	Simulation of leakage inductance of transformer	1,3,4,5,12

Prerequisites: -: Basic Power Electronics

Practical: **(45)**

1. Prepare a flow chart and computer program for optimum design of a small transformer with given specifications and constraints. Use of GUI (Graphical User Interface) may be a better choice.
2. Prepare a flow chart and computer program for optimum design of a DC motor to be used for industrial applications with given specifications and constraints. Use of GUI may be a better choice.
3. Prepare a flow chart and computer program for optimum design of a small DC motor to be used for a lab with given specifications and constraints. Use of GUI may be a better choice.
4. Find leakage inductance of transformer using FEM software. Find force on plunger using FEM software.
5. Design of Electric hybrid vehicle.

COURSE TITLE	Modelling and Simulation of EHV			CREDITS	3
COURSE CODE	EEC3721	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-6		

S.No	COURSE OUTCOMES	PO
1	Elaborate various technical parameters of batteries.	1,2,3,4,5,11,12
2	Distinguish between various types of batteries used for EV applications.	1,2,3,4,5,11,12
3	Develop battery charger for an EV	1,2,3,4,5,11,12
4	Interpret the applications of super capacitors for appropriate storage systems.	1,2,3,4,5,11,12
5	Understand and differentiate different types of fuel cells.	1,2,3,4,5,11,12

Prerequisites : Basics of Modeling and Simulation (MATLAB / SIMULINK)

MODULE I - MODELLING OF VEHICLE PERFORMANCE PARAMETER	9

Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car.	
MODULE II – MODELLING OF BATTERY ELECTRIC VEHICLES	9
Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles	
MODULE III– DRIVETRAIN CHARACTERISTICS	9
Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics-Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis	
MODULE IV– ENERGY MANAGEMENT	9
Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers - RuleBased Control Strategies - Optimization-Based Control Strategies	
MODULE V– Fuel cells	9
Control of Electric and Hybrid Electric Vehicle Dynamics - Fundamentals of Vehicle Dynamic Control (VDC) Systems, VDC Implementation on Electric and Hybrid Vehicles – Case Studies, Rechargeable Battery vehicles, Hybrid Vehicles, Fuel Cell Powered Bus	

REFERENCE BOOKS

1	Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid VehiclesTechnologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.
2	Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", IGI Global, 2013.
3	Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2010.
4	James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.

COURSE TITLE	ELECTRIC VEHICLES IN SMART GRID	CREDITS	3

COURSE CODE	EEC3722	Course Category	DE	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-6		

S.No	COURSE OUTCOMES	PO
1	Describe about vehicle electrification and impact of charging strategies.	1,2,3,4,5,11,12
2	Describe the influence of EVs on power system	1,2,3,4,5,11,12
3	Describe the frequency control and voltage reserve from EVs.	1,2,3,4,5,11,12
4	Describe the frequency control and voltage reserve from EVs.	1,2,3,4,5,11,12
5	Describe the frequency control and voltage reserve from EVs.	1,2,3,4,5,11,12

Prerequisites : : Basics of Electrical Engineering, Automobile engineering and Mechanical engineering

MODULE I – Introduction	9
Introduction, Impact of charging strategies, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, Smart charging technologies, Impact on investment	
MODULE II – INFLUENCE OF EVS ON POWER SYSTEM	9
Introduction, identification of EV demand, EV penetration level for different scenarios, classification based on penetration level, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, case studies	
MODULE III– FREQUENCY CONTROL RESERVES & VOLTAGE SUPPORT FROM EVS	9
Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation.	
MODULE IV– ICT SOLUTIONS TO SUPPORT EV DEPLOYMENT	9
Introduction, Architecture and model for smart grid & EV, ICT players in smart grid, smart metering, information & communication models, functional and logical models, technology and solution for smart grid: interoperability, communication technologies.	
MODULE V– EV CHARGING FACILITY PLANNING	9
Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid, Design of V2G Aggregator.	

REFERENCE BOOKS	
1	Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid, Design of V2G Aggregator.
2	Crouse W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill, 1976.
3	Harald Naunheimer , Bernd Bertsche , Joachim Ryborz , Wolfgang Novak "Automotive Transmission: Fundamentals, Selection, Design and Application", 2nd Edition, Springer, 2011.

COURSE TITLE	TESTING AND CERTIFICATION OF ELECTRIC AND HYBRID VEHICLES		CREDITS	3
COURSE CODE	EEC3723	Course Category: DE	L-T-P-S	3-0-0-1
CIA	50%	ESE	50%	
LEARNING LEVEL		BTL-6		

S.No	COURSE OUTCOMES	PO
1	To understand about the testing of electric vehicle	1,2,3,4,5,11,12
2	To know about the dynamics testing of vehicle	1,2,3,4,5,11,12
3	To understand about retro-fitment and charging station	1,2,3,4,5,11,12

Prerequisites : : Basics of Electrical Engineering, Automobile engineering and Mechanical engineering

MODULE I - INTRODUCTION	6
Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.	
MODULE II – STATIC TESTING OF VEHICLE	9
Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement of Temporary Cabin For Drive– Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.	
MODULE III– DYNAMICS TESTING OF VEHICLE	9

Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.	
MODULE IV– VEHICLE COMPONENT TESTING	9
Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).	
MODULE V– TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION	12
Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.	
REFERENCE BOOKS	
1	"Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators
2	Michael Plint& Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007
3	Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE
4	Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007

COURSE TITLE	**IN-VEHICLE NETWORKING**			**CREDITS**	**3**
COURSE CODE	**EEC3724**	**Course Category**	**DE**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-6**		

S.No	COURSE OUTCOMES	PO
1	Describe about in –vehicle networking	1,2,3,4,5,11,12
2	Explain the different network and communication protocol.	1,2,3,4,5,11,12
3	Explain the different network and communication protocol.	1,2,3,4,5,11,12
4	Describe the flexray protocol	1,2,3,4,5,11,12
5	Describe the latest trends in in–vehicle networking.	1,2,3,4,5,11,12

Prerequisites : : Basics of Electrical Engineering, Automobile engineering and Mechanical engineering

MODULE I - BASICS OF IN-VEHICLE NETWORKING	6
Overview of Data communication and networking –need for In-Vehicle networking – layers of OSI reference model –multiplexing and de-multiplexing concepts –vehicle buses.	
MODULE II – NETWORKS AND PROTOCOLS	9
Overview of general-purpose networks and protocols -Ethernet, TCP, UDP, IP,ARP,RARP - LIN standard overview –workflow concept-applications –LIN protocol specification –signals - Frame transfer –Frame types –Schedule tables –Task behaviour model –Network management –status management - overview of CAN –fundamentals –Message transfer – frame types-Error handling –fault confinement-Bit time requirements.	
MODULE III– HIGHER LAYER PROTOCOL	9
Introduction to CAN open –TTCAN –Device net -SAE J1939 - overview of data channels –Control channel-synchronous channel – asynchronous channel –Logical device model – functions-methods-properties-protocol basics- Network section-data transport –Blocks – frames –Preamble-boundary descriptor	
MODULE IV– FLEXRAY PROTOCOL	9
Introduction –network topology –ECUs and bus interfaces –controller host interface and protocol operation controls –media access control and frame and symbol processing – coding/decoding unit – FlexRay scheduling	
MODULE V– LATEST TRENDS	12
Car networking protocols – Networking future trends –Roadmaps –Competitive advantage	

REFERENCE BOOKS

1	J.Gabrielleen,"Automotive In-Vehicle Networks", John Wiley & Sons, Limited, 2008
2	Robert Bosch," Bosch Automotive Networking", Bentley publishers, 2007
3	Society of Automotive Engineers, "In-Vehicle Networks", 2002

4	Ronald K Jurgen, "Automotive Electronics Handbook", McGraw-Hill Inc. 1999
5	Indra Widjaja, Alberto Leon-Garcia, "Communication Networks: Fundamental Concepts and Key Architectures", McGraw-Hill College; 1st edition, 2000
6	Konrad Etschberger, "Controller Area Network, IXXAT Automation", August 22, 2001
7	Olaf Pfeiffer, Andrew Ayre, Christian Keydel, "Embedded Networking with CAN and CANopen", Annabooks/Rtc Books, 2003

COURSE TITLE	**EV Batteries & Charging System**			**CREDITS**	**3**
COURSE CODE	**EEC3725**	**Course Category**	**DE**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-6**		

S.No	**COURSE OUTCOMES**	**PO**
1	Elaborate various technical parameters of batteries.	1,2,3,4,5,11,12
2	Distinguish between various types of batteries used for EV applications.	1,2,3,4,5,11,12
3	To develop battery charger for an EV	1,2,3,4,5,11,12

Prerequisites : Basics of Electrical Engineering (or equivalent subject)

MODULE I - Battery parameters	6

Cell and battery voltages, Charge (or Amphour) capacity, Energy stored, Energy density, Specific power, Amphour (or charge) efficiency, Energy efficiency, Self-discharge rates, Battery geometry, Battery temperature, heating and cooling needs, Battery life and number of deep cycles

MODULE II – EV Batteries	9

Lead Acid Batteries

Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary

Nickel-based Batteries

Introduction, Nickel cadmium, Nickel metal hydride batteries

MODULE III– Sodium, Lithium and Metal air batteries	9

Sodium-based Batteries

Introduction, Sodium sulphur batteries, Sodium metal chloride (Zebra) batteries

Lithium Batteries

Introduction, The lithium polymer battery, The lithium ion battery

Metal Air Batteries

Introduction, The aluminium air battery, The zinc air battery

MODULE IV– Charging Infrastructure	9
Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.	
MODULE V– EV Charging	12
Battery Chargers: Charge equalisation, Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods	

REFERENCE BOOKS

1	James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
3	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
5	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

COURSE TITLE	MICRO ELECTRO MECHANICAL SYSTEMS			CREDITS	3
COURSE CODE	EEC3726	Course Category	DE	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-6		

S.No	COURSE OUTCOMES	PO
1	Attain a broad range of the knowledge required to grow in the evolving field of MEMS and microsystem	1,2,3,4,5,11,12
2	Familiar with the principle and operation of microsensor and microactuator.	1,2,3,4,5,11,12
3	Select and assess suitable materials for manufacturing MEMS and microsystem.	1,2,3,4,5,11,12
4	Describe the different microfabrication and micromachining process.	1,2,3,4,5,11,12
5	Describe the different stages of microsystems packaging and packaging materials.	1,2,3,4,5,11,12

Prerequisites : Basics of Electrical Engineering (or equivalent subject)	
MODULE I - OVERVIEW OF MEMS AND MICROSYSTEMS	6
MEMS and Microsystems–MEMS as micro sensors and micro actuators- MEMS and Microsystem products– Evolution of Microfabrication, Microsystems and MicroelectronicsComparison of Microsystems and microelectronics-Multidisciplinary nature of MicrosystemsMicrosystems and miniaturization- Applications of Microsystems in various industries.	
MODULE II –MICRO SENSORS AND ACTUATORS	9
Micro sensors- Bio sensors, Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – thermopiles, thermistors. Microactuator - Micro actuation principles-Micro gripperMicro motors-Micro valves-Micro pumps- Micro accelerometers-Micro fluidics0020	
MODULE III– MATERIALS FOR MEMS AND MICROSYSTEMS	9
Substrates and wafers – Silicon as a substrate material, ideal substrates for MEMS – single crystal Silicon and wafers crystal structure – mechanical properties of Si –Silicon compounds – Gallium arsenide- quartz – piezoelectric crystals – polymers.	
MODULE IV– MICROFABRICATION AND MICRO MACHINING	9
Photolithography-Ion Implantation-Diffusion-Chemical vapour deposition (CVD)-Enhanced CVD-Physical vapours deposition (Sputtering)-Etching-chemical etching, plasma etching-Bulk Micro Machining -Surface Micro Machining -LIGA process.	
MODULE V– MICROSYSTEM PACKAGING	12
General considerations in packaging - Levels of Microsystem packaging – die level, device level and system level – Essential packaging technologies – die preparation, surface bonding, wire bonding and sealing - Three-dimensional packaging, assembly of Microsystems – selection of packaging materials.	

REFERENCE BOOKS

1	Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata McGraw Hill, New Delhi, 2017.
2	Mahalik, N. P, MEMS, Tata McGraw Hill, New Delhi, 2007
3	Julian W. Gardner, Florin Udrea, Microsensors: Principles and Applications, Wiley, 2015.
4	Michael Kraft and Neil M. White, MEMS for automotive and aerospace applications, Woodhead Publishing Limited, 2013.
5	Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006
6	Marc F Madou, Fundamentals of Micro Fabrication, CRC Press, 2nd Edition, 2002

COURSE TITLE	Electric and Hybrid Vehicles			CREDITS	3
COURSE CODE	EEC3727	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-6		

S.No	COURSE OUTCOMES	PO
1	Design electric vehicle & HEV for various applications	1,2,3,4,5,6,11
2	Select appropriate motor and converter for EV applications	1,2,3,4,5,6,11
3	Select battery, battery indication system for EV applications	1,2,3,4,5,6,11
4	Design battery charger for an EV	1,2,3,4,5,6,11

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – Introduction to EV & HEV 15

Past, Present & Feature of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.
EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives
EV Parameters: Weight, size, force, energy & performance parameters.

MODULE II – EV Motor Drive 15

DC Motor: Type of wound-field DC Motor, Torque speed characteristics, DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor

Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control

MODULE III– HEV , Energy Sources & Charging 15

HEV: Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow control in all HEV configurations, Examples of HEV system performance
Energy Sources: Different Batteries , Battery characteristics (Discharging &Charging)
Battery Chargers: Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

REFERENCE BOOKS

1	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

2	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

COURSE TITLE	**Electric Motors & Control**			**CREDITS**	**3**
COURSE CODE	**EEC3728**	**Course Category**	**DE**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-6**		

S.No	**COURSE OUTCOMES**	**PO**
1	Understand requirement of EV motors	1,2,3,4,5,11,12
2	Understand suitability of electric motor & their control	1,2,3,4,5,11,12
3	Understand speed control of Induction motor	1,2,3,4,5,11,12
4	Understand PWM techniques of Inverter for Induction motor	1,2,3,4,5,11,12
5	Understand different sensors and sensorless operation of motor	1,2,3,4,5,11,12

Prerequisites : Basics of Electrical Engineering (or equivalent subject)

MODULE I - EV Motors Characteristics and DC motor	6
Requirement of EV motors, Comparison of EV motors, Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation	
MODULE II – DC Motor Dynamics & Control	9
Current Loop Control, Speed Control Loop Dynamical System Control: Gain & Phase Margins, PD Controller, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI Controller with Reference model, Comparison of conventional PI Controller with PI controller with Reference Model, 2 DOF Controller with Internal Model Control, Load Torque Observer, Feedback Linearization, Simplified Modeling of Practical Current Loop	
MODULE III– Induction Motor	9
Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circle diagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor	
MODULE IV– Induction Motor Speed Control	9

Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circle diagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor , Rotor Field oriented control, Stator Field Oriented Control, Field Weakening Control, Variable Voltage Variable Frequency Control,	
MODULE V– PWM and Inverter	12
Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation, Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling, Voltage Model Estimator, Current Model Estimator, Closed-loop MRAS observer, Sliding Mode Observer.	
REFERENCE BOOKS	
1	K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019
2	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
3	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

COURSE TITLE	**Computer Aided Design of Electric Machines**			**CREDITS**	**3**
COURSE CODE	**EEC3729**	**Course Category**	**PC**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-6**		

S.No	**COURSE OUTCOMES**	**PO**
1	Understand the importance of computer aided design method.	1,2,3,4,5,11,12
2	Create software-based design of DC Motor, Induction Motor & Special Electric Motor	1,2,3,4,5,11,12
3	select appropriate motor for EV applications.	1,2,3,4,5,11,12
4	Analysis of machine part with FEM	1,2,3,4,5,11,12
5	Prepare GUI for design of electrical machines.	1,2,3,4,5,11,12

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – CONCEPT OF COMPUTER-AIDED DESIGN AND OPTIMIZATION	12

Introduction; Computer Aided Design; Explanation of details of flow chart; Input data to be fed into the program; Applicable constraints Max or Minimum permissible limits; Output data to be printed after execution of program; Various objective parameters for optimization in an electrical machine; Selection of optimal design; Explanation of lowest cost and significance of "Kg/KVA"; Flowcharts.	
MODULE II – BASIC CONCEPTS OF DESIGN	12
Introduction; Specification; Output coefficient; Importance of specific loadings; Electrical Materials: Conducting Materials, Insulating Materials and Magnetic Materials; Magnetic circuit calculations; General procedure for calculation of Amp-Turns; Heating and Cooling; Modes of heat dissipation; Standard ratings of Electrical machines; Ventilation in rotating machines; Quantity of cooling medium; Types of enclosures; General design procedure; Steps to get optimal design. Application of finite element method in design.	
MODULE III– COMPUTER AIDED DESIGN OF DC MACHINES	9
Introduction; Flowcharts and programs for computer aided design of DC machines. 2D FEM open source software-based DC machine part design	
MODULE VI – COMPUTER AIDED DESIGN OF INDUCTION MOTOR AND SPECIAL MACHINES	9
COMPUTER AIDED DESIGN OF INDUCTION MOTOR: Introduction; Flowcharts and programs for computer aided design of Induction motor, 2D FEM open source software-based Induction motor part desig COMPUTER AIDED DESIGN OF BLDC, SRM and PMSM motors	
REFERENCE BOOKS	
1	K M Vishnu Murthy, Computer aided design of electrical machines. B S Publications
2	Dr. M. Ramamoorthy. Computer- Aided Design of Electrical Equipment. Affiliated East-West press Pvt. Ltd. New Delhi.
3	S.K. Sen, Principles of Electrical Machine Design with Computer Programmes. Oxford & IBH Publishing Co.
4	C.G. Veinott, Computer aided design of FHP motors, McGraw Hill Pub. Co.
5	Maurya, Jallan, Shukla, Computer aided design of electrical machines. Kataria publication
6	Ramu Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press.
7	R. Krishnan, Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and applications, CRC Press
8	K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley Publication.
9	J Reddy, An Introduction to the Finite Element Method. TMH Publication
10	S.J Salon, 'Finite Element Analysis of Electrical Machines', Springer, YesDEE publishers, Indian reprint, 2007.
11	Nicola Bianchi, 'Electrical Machine Analysis using Finite Elements', CRC Taylor & Francis, 2005.

COURSE TITLE	Optimization Techniques			CREDITS	3
COURSE CODE	EEC3730	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-5		

S.No	COURSE OUTCOMES	PO
1	Understand the importance Optimization Techniques	1,2,3,4,5,11,12
2	Understanding about linear programming in power system	1,2,3,4,5,11,12
3	To know about genetic algorithm	1,2,3,4,5,11,12
4	Analysis of particle swarm optimization	1,2,3,4,5,11,12
5	To understand about differential evolution	1,2,3,4,5,11,12

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – Fundamentals of optimization techniques	12

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Lamda Iteration method, Linear programming, Quadratic programming). Brief introduction to lamda iteration method, formulate the Lagrange function, Lamda iteration method to solve Optimal dispatch problem. Introduction to quadratic programming, Working principle, sequential programming, Linear constrained optimization problem, Karush-Kuhn-Tucker conditions and its application to solve various problems, Interior point method, lagrangian duality.

MODULE II – Linear programming	12

Examples of linear programming problem, The Simplex Method I, Fundamental theorem of linear programming, Weak and strong duality theorems, Integer programming, Network flow, develop a linear programming model from problem description.

MODULE III– Genetic Algorithm	9

Introduction to genetic Algorithm, working principle, Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation fitness function. GA operators; Similarities and differences between GA and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm.

MODULE VI – Particle Swarm Optimization	9
Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial	
MODULE V- Differential Evolution	
Fundamental principle, developing DE based solution techniques for OPF problems with single and multiple objectives and comparing the performance and computational effectiveness of DE with other evolutionary and conventional techniques. **Application of population based optimization techniques in power systems:** Algorithms and flow chart of various optimization techniques for solving economic load dispatch and hydro-thermal scheduling problem	

REFERENCE BOOKS

1	S.S.Rao, Engineering Optimization, 3rd Edition, New Age International (P) Ltd.
2	Genetic Algorithm – D.E.Goldberg
3	Principle of soft computing by S.N.Sivanandam & S.N. Deepa
4	Soft computing Technique and its application in electrical Engineering by Chaturvedi,
5	Optimization on Power System Operation by Jizhong Zhu Wiley-IEEE Press.
6	An Introduction to Optimization, 3rd Edition by K.P. Chong, Stanislaw H. Zak.

COURSE TITLE	VEHICULAR NETWORKS AND COMMUNICATION	CREDITS	3

COURSE CODE	EEC3731	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-5		

S.No	COURSE OUTCOMES	PO
1	Understand the importance of Vehicular Networks	1,2,3,4,5,11,12
2	Understanding about Bus system in vehicular communication	1,2,3,4,5,11,12
3	To know about Intelligent Transportation Systems	1,2,3,4,5,11,12

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – Vehicular Networks	12

Vehicular Networks: Cross-System Functions, Requirements For Bus Systems, Classification of Bus Systems, Application In The Vehicle, Coupling of Networks, Examples of Networked Vehicles

MODULE II – Bus System	12

Bus Systems: CAN Bus , CAN-FD, LIN Bus, MOST Bus Bluetooth, Flex Ray,
Diagnostic Interfaces: Implementation of Body Electronics Functionalities Using Controllers.

MODULE III– Vehicular Communication	12

Vehicular Communications: Intelligent Transportation Systems: IEEE 802.11p-ITS-IVC: InterVehicle Communications- Mobile Wireless Communications And Networks- Architecture LayersCommunication Regime.V2V, V2I-VANET-WAVE;DSRC. Information In The Vehicle NetworkRouting-Physical Layer Technologies-Medium Access For Vehicular Communications- SecurityApplications And Case Studies.

REFERENCE BOOKS

1	Dominique Paret, “Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire”, Wiley,2007.
2	Dominique Paret, “FlexRay and its Applications: Real Time Multiplexed Networks”, Second Edition, Wiley,2012
3	Popescu-Zeletin R, Radusch I and Rigani M.A, “Vehicular-2-X Communication”, Springer,2010.
4	Xiang W, “Wireless Access in Vehicular Environments Technology”, Springer, 2015
5	Laun T.H, Shen X.(Sherman) and Bai F, “Enabling Content Distribution in Vehicular AdHoc Networks”, Springer, 2014

COURSE TITLE	Energy Storage Systems and Control	CREDITS	3

COURSE CODE	EEC3732	Course Category	PC	L-T-P-S	3-0-0-1
CIA	50%		ESE	50%	
LEARNING LEVEL			BTL-4		

S.No	COURSE OUTCOMES	PO
1	Discuss about the different types of energy storage system.	1,2,3,4,5,6,11
2	Describe about the battery characteristic & parameters.	1,2,3,4,5,6,11
3	Analyse different types of batteries.	1,2,3,4,5,6,11
4	Apply the concepts of battery management system and design the battery pack.	1,2,3,4,5,6,11
5	Explain about the battery testing, disposal and recycling.	1,2,3,4,5,6,11

Prerequisites : Basic Electrical and Electronics Engineering

MODULE I – ENERGY STORAGE SYSTEM	9

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System
Suggested reading: Study of different types of batteries

MODULE II – BATTERY CHARACTERISTICS & PARAMETERS	9

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parametersHeat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

MODULE III– BATTERY MODELLING	9

General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model, Simulation examples.

MODULE IV– BATTERY PACK AND BATTERY MANAGEMENT SYSTEM	9

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module,
Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

MODULE V– BATTERY TESTING, DISPOSAL & RECYCLING	9

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries , Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

REFERENCE BOOKS

1	Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
2	Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", Springer, 2018. (ISBN: 978-3-319-70571-2)
3	Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley& Sons Ltd., 2016.
4	Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.
5	G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"
6	T R Crompton, "Battery Reference Book-3 rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.
7	James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.
8	G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"

COURSE TITLE	**POWER SYSTEM PLANNING AND RELIABILITY**			**CREDITS**	**3**
COURSE CODE	**EEC3733**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-5**				

CO	**COURSE OUTCOMES**	**PO**
1	Able to analyse and evaluate Planning and forecasting.	2,3,4,5
2	Able to evaluate the reliability in Generation.	2,3,4,5
3	Able to evaluate the reliability in Transmission.	2,3,4,5
4	Able to analyse and evaluate interconnected and Distribution system.	2,3,4,5,12
5	Able to analyse and evaluate expansion Planning.	2,3,4,5,12

Prerequisites : Power system analysis, Power system transmission and distribution, Matrices, Probability and Calculus.

MODULE 1 – PLANNING AND FORECASTING (9L)

Objectives of planning – Long and short term planning - Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting. **Suggested Reading:** Use of AI in load forecasting. **Applications:** Load forecasting using NN
MODULE2–CONCEPTS OF RELIABILITY AND RELIABILITY IN GENERATION (9L)
Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique. Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis. **Suggested Reading:** – corporate model – energy transfer and off peak loading.
MODULE 3- TRANSMISSION SYSTEM AND RELIABILITY ANALYSIS (9L)
Transmission system reliability model analysis – average interruption rate - LOLP method - frequency and duration method - Sub transmission lines and distribution substations- -Design primary and secondary systems **Suggested Reading:** Fuzzy load flow probabilistic transmission system reliability analysis.
MODULE 4– INTERCONNECTED SYSTEMS (9L)
Two plant single load system - two plant two load system - load forecasting uncertainty - Interconnections benefits- Introduction to system modes of failure – the loss of load approach – frequency & duration approach. **Suggested Reading:** spare value assessment – multiple bridge equivalents
MODULE 5– EXPANSION PLANNING (9L)
Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system **Suggested Reading:** distribution system protection and coordination of protective devices.

	TEXT BOOKS
1	Sullivan, R.L., 'Power System Planning', Heber Hill, 1987.Digitized 5 August 2011
2	Roy Billington,Ronald L Allan, 'Reliability Evaluation of Power System', Springer USA , 1996
3	*Eodrenyi, J., 'Reliability Modelling in Electric Power System' John Wiley, 1980.*
	REFERENCE BOOKS
1	Knight, U.G., Power System Engineering and Mathematics, Pergamum Press (1972),Reprint 2011
2	X. Wang & J.R. McDonald, "Modern Power System Planning", McGraw Hill Book Company,1994.
3	Hossein Seifi, Mohammad Sadegh Sepasian Electric,' Power System Planning Issues, Algorithms and Solutions',Springer,2011
4	Roy Billington, 'Power System Reliability Evaluation', Gordan & Breach Scain Publishers,1990
5	Pabla, A.S., Electric Power Distribution, Tata McGraw–Hill (2008)
	E BOOKS
1	Hossein Seifi, Mohammad Sadegh Sepasian Electric,' Power System Planning Issues, Algorithms and Solutions',Springer,2011

2	Roy Billington, Ronald L Allan, 'Reliability Evaluation of Power System', PLENUM PRESS • NEW YORK AND LONDON,
MOOC	
1	PDH online Course E485 (2 PDH) Basic Reliability Analysis of Electrical Power Systems Velimir Lackovic, MSc EE, P.E.
2	NTNU ET8207 - Power System Reliability
3	Gerorgia Tech SECE ECE6322Power System Planning and Reliability.

COURSE TITLE	**POWER SYSTEM AUTOMATION**			**CREDITS**	**3**
COURSE CODE	**EEC3734**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 0**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	To understand the concepts of power system automation.	2,3,4,5
2	To understand the components of SCADA systems.	2,3,4,5
3	To comprehend the RTU, IED and other components of automation systems	2,3,4,5
4	To understand the transfer of signals from the field to an operator control terminal.	2,3,4,5
5	To design an interoperable powers automation system.	2,3,4,5,12

Prerequisites : Basic Knowledge of Transmission & Distribution systems and Measuring Instruments

MODULE 1-INTRODUCTION TO SCADA (9L)

Evolution of Automation systems, History of Power system Automation, Supervisory Control And Data Acquisition(SCADA) Systems, Components of SCADA systems, SCADA Applications, SCADA in power systems, SCADA basic functions, SCADA application functions in Generation, Transmission and Distribution.

Suggested Reading: SCADA based protection system

Applications: Comprehensive operational planning and control, Network security, Economic dispatch

MODULE 2-SCADA SYSTEM COMPONENTS (9L)

Advantages of SCADA in Power Systems, The Power system 'Field', Types of data &signals in the Power system, Flow of Data from the field to the SCADA Control center. Building blocks of SCADA systems, Classification of SCADA systems.

Suggested Reading: Operation and control of interconnected power system

MODULE 3-FEATURES OF RTU (9L)

Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication, Logic, Termination and Test/HMI Subsystems, Power supplies, Advanced RTU Functionalities.

Suggested Reading: Microcontroller based RTU for distribution automation system

Applications: RTU for Distribution Automation and Substation Monitoring applications

MODULE 4-COMMUNICATION SYSTEM STANDARDS FOR SCADA (9L)

Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED functional block diagram, The hardware and software architecture of IED, IED Communication subsystem, IED advanced functionalities, Typical IEDs, Data Concentrators and Merging Units, SCADA Communication Systems.
MODULE 5-FEATURES OF HMI (9L)
Master Station, Master station software and hardware configurations, Server systems in the master station, Small, medium and large master station configurations, Global Positioning Systems, Master station performance, Human Machine Interface (HMI), HMI components, Software functionalities, Situational awareness, Case studies in SCADA. **Suggested Reading:** SCADA Simulation of a distributed generation system **Applications:** Utility applications
LAB / MINI PROJECT/FIELD WORK
Introduction to electrical Supervisory Control & Data Acquisition (eSCADA) using ETAP

TEXT BOOKS	
1	Mini S. Thomas, John D McDonald, Power Systems SCADA and Smart Grid, CRC Press, Taylor and Francis, 2015.
2	Electric Power Substation Engineering John D. Mc Donald CRC Press, Taylor and Francis, 2012.
REFERENCE BOOKS	
1	Control and Automation of Electrical Power Distribution systems, James North cote- Green, R Wilson, CRC Press, Taylor and Francis, 2006.
2	Electric Power Distribution, Automation, Protection and Control, James Momoh, CRC press, Taylor and Francis, 2008.
3	Biswarup Das, Power Distribution Automation, IET, 2016.
E BOOKS	
1	https://epdf.tips/queue/electric-power-distribution-automation-protection-and-controla630f51c023e86aff603a2bad92c5f6e35450.html
2	https://epdf.tips/queue/control-and-automation-of-electrical-power-distribution-systems.html
3	https://epdf.tips/queue/automation-in-electrical-power-systems.html
MOOC	
1	https://nptel.ac.in/courses/108106022/11
2	https://www.udemy.com/topic/scada/
3	https://www.tru.ca/distance/courses/wttp2311.html

COURSE TITLE	**ENERGY AUDITING AND MANAGEMENT**			**CREDITS**	**3**
COURSE CODE	**EEC3735**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0-1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1	Assess the energy management on various electrical equipment and metering	2,3,4,5,12
2	Adopt Conservation methods in various systems.	2,3,4,5,12
3	Learn various technically proven ways to conserve Energy and then prioritize them based on the cost benefit analysis	2,3,4,5,12
4	Illustrate the concept of lighting systems and cogeneration.	2,3,4,5,12
5	Apply Tools for energy audit and recommend measures for energy conservation	2,3,4,5,12

Prerequisites : Nil		
MODULE 1 INTRODUCTION		**(9L)**
Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting-energy audit process. **Suggested Reading:** Study of energy audit report		
MODULE 2 ENERGY COST AND LOAD MANAGEMENT		**(9L)**
Important concepts in an economic analysis - Economic models-Time value of money- Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification. **Suggested Reading:** Analysis of different economic models		
MODULE 3 ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT		**(L9)**
Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance. **Suggested Reading:** Savings calculation after implementing the above methods		
MODULE 4 METERING FOR ENERGY MANAGEMENT		**(9L)**
Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters – Metering location vs. requirements **Suggested Reading:** Metering techniques and practical examples		
MODULE 5 LIGHTING SYSTEMS & COGENERATION		**(9L)**
Concept of lighting systems - The task and the working space -Light sources - Ballasts –Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection. **Suggested Reading:** Electrical Design of Buildings		
TEXT BOOKS		
1	Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.	
2	Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006	
3	Energy management by W.R. Murphy & G. Mckay Butter worth, Heinemann publications. 2016	
REFERENCE BOOKS		
1	Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995	
2	Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998	
E BOOKS		
1	Wayne C. Turner, " Energy Management Handbook" The Fairmont Press, 2001	

2	http://www.em-ea.org/guide%20books/book-/1.3%20energy%20management%20&%20audit.pdf
MOOC	
1	https://www.coursera.org/learn/energy-101
2	https://www.coursera.org/learn/future-of-energy

COURSE TITLE	**DISTRIBUTED GENERATION AND MICRO-GRIDS**			**CREDITS**	**3**
COURSE CODE	**EEC3736**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand the current scenario of Distributed Generation and the need to implement DG sources.	2,3,4
2	Investigate the different types of RES as DGs.	2,3,4
3	Appraise the grid integration ,interfaces and technical impacts of DGs upon transmission and distribution systems	2,3,4,5
4	Analyze the aspects of Power Quality and Reliability.	3,4,5,12
5	To understand comprehensively about different types of Storage systems.	3,4,5,12

Prerequisites : The students are preferred to have a basic knowledge in Power System Analysis and DistributionSystems

MODULE 1 – INTRODUCTION , PLACING AND SIZING THE DISTRIBUTED ENERGY RESOURCES (9L)

Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.

Suggested Reading: Detailed study of Renewable Energy Sources

Applications: Siting and Sizing of DGs using ETAP

MODULE 2 –RENEWABLE ENERGY SOURCES (9L)

Wind Power-Photovoltaic and Thermo-solar power-Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes.

Suggested Reading: Micro turbines for DG, bulb and tubular turbines-

MODULE 3 –GRID INTEGRATION , INTERFACES AND IMPACTS OF DGS . (9L)

Grid integration of DGs – Different types of interfaces - Inverter based DGs - Aggregation of multiple DG units. – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying

Suggested Reading: Rotating machine based interfaces

MODULE 4 – POWER QUALITY AND RELIABILITY IN DER (9L)

Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis.

Suggested Reading: Various aspects of Operations

MODULE 5 –ENERGY STORAGE AND CONTROL TECHNIQUES (9L)	
Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra-capacitors and Mechanical Storage: Flywheels, Pumped and Compressed Fluids. Control Techniques for DER integration systems- Standards and codes for interconnection- future structure of grid. **Suggested Reading:** Various aspects such as Market Management Retailing , Trading and Ancillary Services	
LAB / MINI PROJECT/FIELD WORK	
Simulation in ETAP/HOMER	
TEXT BOOKS	
1	"Distributed Power Generation, Planning & Evaluation" by H. Lee Willis & Walter G. Scott, 2000 Edition, CRC Press Taylor & Francis Group.
2	"Renewable energy power for a sustainable future" by Godfrey Boyle ,2004 Oxford University Press in association with the Open university.
3	Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
4	Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
REFERENCE BOOKS	
1	Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson 'Facility Microgrids', Subcontract report, May 2005,
2	Mohammad Shahid ehpour, M. Alomoush, Restructured Electrical Power Systems: Operation: Trading, and Volatility, CRC Press, 2001
3	N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, The Institution of Engineering and Technology,2010
4	S. Chowdhury, S.P. Chowdhury and P. Crossley,' Microgrids and Active Distribution Networks', The Institution of Engineering and Technology
E BOOKS	
1	N. Jenkins, J.B. Ekanayake and G. Strbac,Distributed Generation, The Institution of Engineering and Technology,2010
2	S. Chowdhury, S.P. Chowdhury and P. Crossley,'Microgrids and ActiveDistribution Networks', The Institution of Engineering and Technology
MOOC	
1	Micro grid, Course era .
2	Introduction to Smart Grid, NPTEL online
3	Solar Energy: Integration of Photovoltaic Systems in Microgrids ,EDX
4	Distributed Energy - Smart Grid Resources for the Future , EDX

COURSE TITLE	PHOTOVOLTAIC AND FUEL CELL SYSTEMS	CREDITS	3

COURSE CODE	EEC3741	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-5				

CO	COURSE OUTCOMES	PO
1	Understand and analyse the fundamental concepts of solar PV systems	2,3,4,5,12
2	Design a solar PV power plants and its components	2,3,4,5,12
3	Understand and analyse the fundamental concepts of fuel cells	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - SOLAR PV SYSTEMS (L12)

Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Supporting structures, mounting and installation, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule, Monitoring, Data Management, Performance Analysis and Financial Analysis

MODULE 2 - SOLAR PV POWER PLANTS (L12)

Array design, inverter types and characteristics, Power conditioning system: working algorithms, performance analysis; design of standalone, hybrid and grid interactive plants, commissioning of solar PV plant

MODULE 3 - FUEL CELLS (L12)

Thermodynamics of fuel cells; free energy change and cell potentials; effects of temperature and pressure on cell potential; energy conversion efficiency; factors affecting conversion efficiency; polarization losses; important types of fuel cells (hydrogen-oxygen, organic compounds-oxygen, carbon or carbon monoxide-air, nitrogen compounds-air); electrode types; electrolytes for fuel cells; applications.

TEXT BOOKS

1. Chetan Singh Solanki, Solar Photovoltaic Technology And Systems: A Manual For Technicians, Trainers And Engineers PHI Learning Pvt. Ltd..,New Delhi 110092, 2013
2. A. K. Mukerjee, Nivedita Thakur, Photovoltaic Systems: Analysis And Design, Phi Learning Pvt. Ltd..,New Delhi 110001, 2011
3. Shripad T. Revankar, Pradip Majumdar, Fuel Cells: Principles, Design, And Analysis, CRC Press, 2014
4. N.K. Bansal, Non-Conventional Energy Resources, Vikas Publishing House Pvt Ltd, New Delhi , 2014

REFERENCE BOOKS

1. Roger A. Messenger, Amir Abtahi, Photovoltaic Systems Engineering ,4th Edition, CRC Press, 2017 (ISBN 9781498772778 - CAT# K29524)
2. Michael Boxwell , Solar Electricity Handbook - 2015 Edition: A simple, practical guide to solar energy - designing and installing solar PV systems.Green Stream Publishing, United Kingdom,2015
3. B. Viswanathan, M. Aulice Scibioh, **Fuel Cells**: **Principles and Applications**, Taylor & Francis Group, 2007

E BOOKS	
1	https://courses.edx.org/c4x/DelftX/ET.3034TU/asset/solar_energy_v1.1.pdf
2	http://unesdoc.unesco.org/images/0013/001332/133249e.pdf
MOOC	
1	https://online.stanford.edu/courses/matsci256-solar-cells-fuel-cells-and-batteries-materials-energy-solution
2	https://www.mooc-list.com/course/solar-energy-photovoltaic-pv-systems-edx
3	https://www.coursera.org/lecture/energy-environment-life/fuel-cells-and-hydrogen-economy-c0VKy

COURSE TITLE	WIND AND HYDRO ENERGY SYSTEMS			CREDITS	3
COURSE CODE	EEC3742	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Understand and analyse the fundamental concepts wind energy power generation	2,3,4,5,12
2	Understand and analyse the operation and control of wind energy converter	2,3,4,5,12
3	Understand and analyse the concepts and components of hydro power generation	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - WIND ENERGY (12L)

Basics :Status, Advantages and disadvantages of wind energy systems, Advantages and disadvantages, Types of wind energy converters, local Effects on wind, site selection: roughness length, wind shear, Wind Speed Variability, Obstacles to wind flow,

Working principles of wind energy: Energy content in wind, Energy Conversion at the Blade, Wind variations: Weibull distribution.

MODULE 2 - COMPONENTS , OPERATION AND CONTROL OF A WIND ENERGY CONVERTER (12L)

Components of a wind energy converter: Rotor Blades, Gearboxes, Synchronous or Asynchronous Generators, Towers, Miscellaneous components, Turbine Selection

Operation and Control of Wind Energy Converters: grid requirements, Issue of Noise and Its Control, Power Curve and Capacity Factor, Pitch control, Stall Control, Yaw Control

MODULE 3 - HYDRO POWER (12L)

Hydropower basics: Water Cycle in Nature, Classification of Hydropower Plants, Status of Hydropower Worldwide, Advantages and Disadvantages of Hydropower, Operational Terminology, Legal Requirements

Working principles: Locating a Hydropower Plant, Basics of Fluid Mechanics for hydro power, single and multiple reservoir system, cascaded power plants

Important Parts of Hydropower Station: Turbine, Electric Generator, Transformer and Power House, Structural parts: Dam and Spillway, Surge Chambers, Stilling Basins, Penstock and Spiral Casing, Tailrace, Pressure Pipes, Caverns, auxilliary parts. Hydraulic turbines: Classification of Hydraulic Turbines, Theory of Hydro Turbines: Francis, Kaplan, Pelton turbines, efficiency and selection of turbine	
TEXT BOOKS	
1	Nag P K. Power Plant Engineering, 3rd Edition, Tata McGraw Hill, 2008
2	Jain P. Wind Energy Engineering. McGraw-Hill 2011
3	Wagner H. Mathur J. Introduction to Hydro energy Systems : Basics, Technology and Operation, Springer, 2011
4	Bansal RK. A textbook of fluid mechanics and hydraulic machines. Laxmi Publications, 20 05, New Delhi
REFERENCE BOOKS	
1	Johnson GL. Wind Energy Systems, (Electronic Edition), Prentice Hall Inc, 2006
2	Mathew S. Wind Energy: Fundamentals, Resource Analysis and Economics. Springer, 2006
3	Hussian Z. Abdullah MZ. Alimuddin Z. Basic Fluid Mechanics and Hydraulic Machines. CRC Press, 2009.
E BOOKS	
1	https://nptel.ac.in/courses/108105058/24
2	https://nptel.ac.in/courses/108108078/6
3	https://www.nrel.gov/docs/fy13osti/54909.pdf
4	https://www.usbr.gov/power/edu/pamphlet.pdf
5	https://ieeexplore.ieee.org/document/6533416
MOOC	
1	http://www1.rmit.edu.au/courses/045838
2	https://www.coursera.org/lecture/electric-utilities/1-7-renewables-hydroelectric-and-wind-B3YMk

COURSE TITLE	**BIOMASS ENERGY SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EEC3743**	**COURSE CATEGORY**	**OE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand the fundamental concepts of Biomass	1,2,3,4,5,12
2	analyse the operation and control of biomass and biogas	1,2,3,4,5,12
3	Understand and analyse the industrial and power generation aspects of biomass	1,2,3,4,5,12

Prerequisites : Nil

MODULE 1 - BIOMASS RESOURCE (L12)

Characteristics of Biomass fuel, technologies for using biomass, comparison of direct combustion with other technologies

MODULE 2 - BIOMASS GASIFIERS AND INDUSTRIAL USE OF BIOMASS (L12)

Biomass Gasifiers: Basics of Gasification and types of Gasifiers, Thermodynamic Analysis Biogas Technology, Sizing/Selection and design of Gasifiers, Industrial use of biomass: Industrial Boilers, biomass as fuel, co-firing and co-generation, Economic analysis, Testing and Performance Evaluation of Gasifiers, Use of biomass for liquid fuel, Biomass policy	
MODULE 3 - BIOGAS	**(L12)**
Types of biogas plants, design and performance analysis, application of biomass	
TEXT BOOKS	
1	Biomass Assessment Handbook - Bioenergy for a sustainable environment, Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006
2	Success & Visions for Bioenergy: Thermal processing of biomass for bioenergy, biofuels and bioproducts, Edited by A V Bridgwater, CPL Press September 2007.
REFERENCE BOOKS	
1	Alternate Energy: Assessment & Implementation Reference Book, James J Winebrake, Springer January 2007.
2	Biofuels - Securing the Planet's Future Energy Needs, Edited by A Demirbas Springer 2009.
3	Energy Technology and Directions for the Future, John R. Fanchi, Elsevier Science February 2004
E BOOKS	
1	https://nptel.ac.in/courses/108108078/7
2	https://nptel.ac.in/downloads/108108078/
3	http://www.cigr.org/documents/CIGRHandbookVol5.pdf
4	https://www.crcpress.com/Principles-of-Sustainable-Energy-Systems-Third-Edition/Kutscher-Milford-Kreith/p/book/9781498788922
5	https://link.springer.com/referencework/10.1007/978-1-4614-5820-3
MOOC	
1	https://www.edx.org/course/sustainable-energy-design-a-renewable-future

COURSE TITLE	**Artificial Neural Network & Fuzzy Logic Applications**			**CREDITS**	**3**
COURSE CODE	**EEC3744**	**Course Category**	**DE**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**		**ESE**	**50%**	
LEARNING LEVEL			**BTL-6**		

S.No	**COURSE OUTCOMES**	**PO**
1	Understand how the soft computing techniques can be used for solving the problems of power electronics and motor drives essential for electrical or hybrid vehicle.	1,2,3,4,5,11,12
2	Apply ANN based systems for function approximation in signal estimation for vector drives.	1,2,3,4,5,11,12
3	Apply the algorithms of deep learning in problem of control power quality identification.	1,2,3,4,5,11,12
4	Design of Fuzzy based systems for load frequency control in power systems.	1,2,3,4,5,11,12

5	Develop and evaluate control systems required in operations of power electronics equipment.	1,2,3,4,5,11,12

Prerequisites : Basics Mathematics with computer language programming.

MODULE I - Introduction	6
The AI Problems, The Underlying Assumption, AI Techniques, Difference between soft computing techniques and hard computing systems, Expert systems brief history of ANN and Fuzzy Logic.	

MODULE II – Artificial Neural Network	9
Introduction, History of neural network research, Basic concepts of Neural Networks, Human brain, Model of Artificial Neuron, Neural Network architectures, Perceptron, Single layer feed forward Network, Multi layer feed forward network, Recurrent networks (RNN), Feedback networks and Radial Basis Function Networks, Characteristics of NN, Learning Methods, LMS and Back Propagation Algorithm, training Examples of models, Advances in Neural networks	

MODULE III– Deep Learning	9
Convolution Neural Network (CNN): Neuron in human vision, Shortcoming of feature selection, Filters and feature maps, Full Description of Convolution neural network (CNN), Max pooling. Principal component analysis, Autoencoder: Architecture, Sparsity. Long short term memory units in RNN	

MODULE IV– Fuzzy Logic	9
Introduction, Comparison between Fuzzy and crisp logic, Fuzzy sets, Membership function, Basic fuzzy set operations, Properties of Fuzzy set, fuzzy relations, Fuzzy interference system, Mamdani, Sugeno, Fuzzy rule based system, Defuzzification methods, Fuzzy Neural Networks	

MODULE V– Real time Applications	12
ANN in space vector PWM wave synthesis for 2-level and multi-level converters. Static feedback signals estimation for a vector drive, space vector PWM for a two-level voltage-fed inverter and voltage model flux vector estimation. Model referencing adaptive control (MRAC) of ac drives, drift-free flux estimation of drives. Fuzzy logic based control replacing PID controller Neuro-fuzzy control of drives.	

REFERENCE BOOKS

1	Neural Networks, Fuzzy logic and Genetic algorithms By S. Rajasekaran, G. A. Vijayalakshmi Pai PHI publication
2	Principles of Soft computing, Wiley, 2nd Edition, S. N. Deepa and S. Sivanandam.
3	Introduction to Neural Networks using MATLAB 6.0, McGraw Hill Education, S. Sivanandam, S. Sumathi, S. N. Deepa.
4	Neural Network: A Comprehensive Foundation, second edition, Pearson Prentice Hall, Simon Haykin.
5	Deep learning with python: A Hands-on Introduction, Apress, Nikhil Ketkar
6	Fundamentals of Deep Learning, O' Reilly, Nikhil Baduma Nicholas Locasio.

7	Artificial intelligence techniques in power systems by KEVIN WARWICK, ARTHUR EKWUE RAJ AGRAWA

COURSE TITLE	**SEMINAR**				**2**
COURSE CODE	**EEC3796**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**0-0-3-0**
CIA	**60%**		**ESE**	**40%**	
LEARNING LEVEL	**BTL-6**				

CO	**COURSE OUTOMES**	**PO**
1	Able to develop simple electric vehicle and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

SEMINAR

Seminar **s**hould be taken on state of the art topic of student's own choice based on relevant specialization approved by an Department incharge. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

COURSE TITLE	**MINI PROJECT**				**2**
COURSE CODE	**EEC3780**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**0-0-3-0**
CIA	**60%**		**ESE**	**40%**	
LEARNING LEVEL	**BTL-6**				

CO	**COURSE OUTOMES**	**PO**
1	Able to develop simple electrical and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

MINI PROJECT

To carry out a mini project and simple prototype in the area of interest based on the knowledge gained in Electrical and Electronics Engineering from undergraduate and first semester

The students will carry out a project in one of the following Electrical and Electronics Engineering areas but with substantial multidisciplinary components:

- Power Electronics, Control system
- Energy storage devices.
- Electrical Machines, Solid State Drives etc. . .

Every individual student will be assigned a faculty to guide them. There will be three major reviews which will be carried out as listed below.

Review #	Requirement	Mark Weightage	
		Internal	External
0	Area / Title selection	-	-
1	Literature review / Proposal for the Project	10%	-
2	Mathematical modelling/Circuit Design	20%	-
3	Final simulation / Hardware presentation	20%	-
End Semester Exam	Final Viva-Voce and project demonstration	-	50%