PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY AND G K PATE (WANI) INSTITUTE OF MANAGEMENT PUNE-9

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)

DEPARTMENT OF ELECTRICAL ENGINEERING

CURRICULUM BOOK

BE Electrical – 2019 Pattern

FOR THE PROGRAMME

FOURTH YEAR – ELECTRICAL ENGINEERING

PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY AND G K PATE (WANI) INSTITUTE OF MANAGEMENT PUNE-9

VISION

TO ACHIEVE EXCELLENCE IN ENGINEERING EDUCATION

MISSION

- **To satisfy all stakeholders**
- **To develop ethical, highly motivated engineering professionals with good human values, requisite skills and competencies**
- **To adopt innovative teaching mechanisms**
- **To promote research culture**
- **To contribute to country's economic development**
- **To be responsive to changes in technology, socio-economic and environmental conditions**

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To develop Electrical Engineering Department as one of the premier facility centre for disseminating the state of the art education.

MISSION

- **Providing Quality education in the field of Electrical Engineering.**
- **Developing State of the art facilities in the department.**
- **Creating platform Training, Research and Development**
- **Producing Sound electrical engineers catering need of industry and other stake holders.**

PROGRAM EDUCATIONAL OBJECTIVES

PEO1:- Electrical Engineering Graduate will demonstrate knowledge base of Electrical Engineering to excel in industry and higher studies.

PEO2:- Electrical Engineering Graduate will exhibit competency in analytical abilities and problem solving capabilities on the basis of strong fundamentals in Electrical Engineering.

PEO3:- Electrical Engineering Graduate will develop sustainable solutions for society with ethics and professionalism.

PEO4:- Electrical Engineering Graduate will show professional qualities such as team work, leadership, entrepreneurial thinking and communication skills.

PEO5:- Electrical Engineering Graduate will be habitual to lifelong learning abilities.

PROGRAMME OUTCOMES

Electrical Engineering Graduates will have:

PO1: Engineering Knowledge: An ability to apply knowledge of mathematics, science and Engineering fundamentals to analyze complex engineering problems.

PO2: Problem Analysis: An ability to identify, formulate and analyze complex engineering problems by reviewing research literature to arrive at substantiated conclusions.

PO3: Design/Development of Solutions: An ability to design solutions for complex engineering problems, system components or processes to meet the specified needs of the society, considering safety and environment.

PO4: Conduct Investigations of Complex problems: Ability to carry out experiments, simulations and apply research methodologies to investigate the data for providing valid conclusions.

PO5: Modern tool usage: An ability to select and apply appropriate techniques, resources and modern engineering tools such as advanced controllers and application softwares for engineering activities

PO6: The Engineer and society: An ability to assess and develop professional engineering practices catering the need of society considering safety, health, regulatory and other relevant issues.

PO7: Environment and sustainability: An ability to apply professional engineering knowledge to understand the impact on society and environment demonstrating the need for the sustainable development.

PO8: Ethics: An ability to adopt professional ethics while committing professional and social responsibilities.

PO9: Individual and Team work: An ability to develop multidisciplinary skills as an individual and as a member or leader in diverse teams.

PO10: Communication: An ability to communicate effectively with engineering community and society at large with effective documentation and presentation on engineering activities.

PO11: Project management and Finance: An ability to demonstrate knowledge of Engineering and Management principles as a member or a leader to manage project and multidisciplinary tasks.

PO12: Life-long Learning: An ability to understand need and develop the habit of being lifelong learner to adopt to technological changes.

PROGRAMME SPECIFIC OUTCOMES

PSO1: An ability to acquire adequate proficiency in the area of Energy Systems and Sustainability.

PSO2: An ability to acquire multidisciplinary skills in the area of Control and Drives.

PSO3 : An ability to acquire enhanced skills and core competency in the field of Electrical Engineering through hands on training.

INDEX

Fourth Year

Curriculum Book

BE Electrical (2019 Course) – Semester - I

Course Code	Subject Title	Teaching Scheme (Hrs/Week)				Examination Scheme (Marks)					Total	Credits				
		TH	PR	TU	PW	PP		TW	PR	OR		Th	Pr	Tu	PW	Total
						In Sem	End Sem									
403141	Power System Operation and Control	03	02	--	-	30	70	25	--	25	150	3	1	-	-	4
403142	Advanced Control System	03	02	--	-	30	70	--	--	50	150	3	1	-	-	4
403143 A	Elective I PLC and SCADA Applications	03	02	--	-	30	70	25	--	--	125	3	1	-	-	4
403143 B	Elective I Power Quality	03	-02	--	-	30	70	--	--	--	100	3	1	-	-	4
403144 A	Elective II Alternate Energy Systems	03	-	02	-	30	70	25	--	25	150	3	-	1	-	4
403144 B	Elective II Electric & Hybrid Vehicle	03	--	02	-	30	70	--	--	50	50	3	-	1	-	4
403145	Project Stage – I	-	-	-	4	-	-	-	-	-	-	-	-	-	2	2
403146	MOOCs	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
403147	Audit Course - VII	02 #	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		12	6	2	4	120	280	150	-	150	700	12	3	1	4	20

403143 : Elective I	403144 : Elective II	403147 : Audit Course - VII
403143 A PLC and SCADA	403144A : Alternate Energy System	403147 A: German Language
403143 B Power Quality Management	403144 B Electrical & Hybrid Vehicle	403147 B Engineering Economics I
403143 C High Voltage Engineering	403144 C Special-purpose Machines	403147 C Sustainability(IGBC)
403143 D Robotics and Automation	403144 D HVDC & FACTS	

BE Electrical (2019 Course) – Semester - II

Course Code	Subject Title	Teaching Scheme (Hrs/Week)				Examination Scheme (Marks)					Total	Credits				
		TH	PR	TU	PW	PP		TW	PR	OR		Th	Pr	Tu	PW	Total
						In Sem	End Sem									
403148	Switchgear and Protection	03	02	--	-	30	70	25	-	50	175	3	1	-	-	4
403149	Advanced Electrical Drives & Control	03	02	--	-	30	70	25	50	-	175	3	1	-	-	4
403150 A	Elective III Smart Grid	03	-	--	-	30	70	-	--	--	100	3	-	-	-	3
403151 A	Elective IV Illumination Engineering	03	-	--	-	30	70	--	--	--	100	3	-	-	-	3
403152	Project Stage – II	-	-	-	12	-	-	100	-	50	150	-	-	-	6	6
403153	Audit Course - VIII	02 #	-	-	-	-	-	-	-		-	-	-	-	-	-
Total		12	4	-	12	120	280	150	50	100	700	12	2	-	6	20

403150: Elective-III	403151: Elective-IV	403153: Audit Course-VIII
403150 A : Digital Control System 403 150)	403151A: EHV AC Transmission	403153A: German Language II
403150 B : Restructuring and Deregulation	403151B : Illumination Engineering	403153B: Engineering Economics II
C: Smart Grid 403150	403151C: Electromagnetic Fields	403153C: Green Building
D: SensorTechnology (Open Elective	403151D: AI and ML (Open Elective)	

BE (ELECTRICAL)

Semester I&II

Power System Operation and Control

Course Name : Power System Operation and Control **Course Number : 403141**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits :** **Theory : 03** **Oral : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral : 50 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
PS – II Course at TE Elect PS – I Course at SE Elect		

Course Objectives:	
1.	Study the different types of angle, voltage and frequency stability of the power system and methods to improve the stability of the power system.
2.	Impart knowledge about various advanced controllers such as FACTs controllers with its evolution, principle of operation, circuit diagram and applications.
3.	Understand the formulation of unit commitment and economic load dispatch.

Course Outcomes: At the end of the course, a graduate will be able to –		
CO1.	Summarize angle, voltage and frequency stability in the power system control (UN).	Create
CO2.	Illustrate various ways of interchange of power between interconnected utilities (AP).	Apply / Analyze
CO3.	Analyze stability and optimal load dispatch using different techniques (AN).	Apply
CO4.	Select appropriate FACTS devices for stable operation of the system (EV).	Evaluate / Create
CO5.	Evaluate the stability of the system and suggest the methods to improve it EV).	Understand / Analyze

Course Contents :		
Unit 1 :	**Power System Stability (Angle Control)**	**[6 Hrs]**
Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and reclosure), methods to improve steady state and transient stability, numerical based on equal area criteria.		
Practical :	• To apply equal area criteria for stability analysis under a fault condition (three-phase fault at the middle point of a parallel transmission line). • Plot a swing curve using the point-by-point/4th order Runge-Kutta method. • To apply equal area criteria for analysis stability under a sudden rise in mechanical power input.	

Unit 2 :	**Reactive Power Control**	**[6 Hrs]**
The necessity of reactive power control, production and absorption of reactive power, reactive power requirements for power factor control and voltage regulation and the loading capability curve of a synchronous generator, types of FACTS controller. **Series compensation:** reactor and capacitor, TCSC, SSSC. **Shunt compensation:** reactor and capacitor, STATCOM, FC-TCR. **Series and shunt compensation:** UPFC. (FACTS devices: working principle, circuit diagram, VI characteristics, applications)		
Practical :	• To study reactive power compensation using STATCOM. • To study reactive power compensation using simulation of TCR or TCSC.	
Unit 3 :	**Automatic Generation Control (Frequency Control)**	**[6 Hrs]**
Introduction to the concept of AGC; complete block diagram representation of load-frequency control of an isolated power system; steady state and dynamic response; control area concept; two-area load-frequency control; Schematic and block diagram of the alternator voltage regulator scheme.		
Practical :	• To study load frequency control using an approximate and exact model. • To study load frequency control with proportional and integral control. • To study the two area of load frequency control.	
Unit 4 :	**Economic Load Dispatch and Unit Commitment (Cost Control)**	**[6 Hrs]**
Part A: Economic load dispatch: Introduction, revision of cost curve, incremental cost curve of thermal, method of Lagrange multiplier, exact coordinate equation (penalty factor), economic scheduling of thermal plant considering effect of transmission losses using Bmn coefficient. (Numerical on method of Lagrange multiplier, penalty factor, Bmn coefficient) **Part B: Unit commitment:** Concept of unit commitment, constraints in unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming, Numerical on priority list and dynamic programming method.		
Practical :	• To study the Lagrange multiplier technique for economic load dispatch (to find the optimal loading of generators). • To solve the Unit Commitment problem by priority list method/ dynamic programming (DP) approach • To study the optimum loading of generators considering transmission losses (penalty factor).	
Unit 5 :	**Energy Control**	**[6 Hrs]**
Interchange of power between interconnected utilities (numerical), economic interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.		
Unit 6 :	**Voltage Stability**	**[6 Hrs]**
Basic concepts related to voltage stability: transmission system characteristics (PV curve), generator characteristics (QV curve), and load characteristics. Voltage collapse, classification of voltage stability, static and dynamic stability, analysis techniques for dynamic voltage stability, voltage stability indexing.		

Text Books:	
[T1]	I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", 4th Edition, Tata McGraw Hill Publishing Co. Ltd. (Edition 2)
[T2]	Hadi Saadat, "Power System Analysis," Tata McGraw's Hill
[T3]	P. S. R. Murthy, "Power System Operation and Control," Tata McGraw-Hill Publishing Co., Ltd.
[T4]	S. Sivanagaraju, G. Sreenivasan, "Power System Operation and Control," Pearson Education India, 2009.
[T5]	Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTs," IEEE Press.
Reference Books:	
[R1]	Allen J. Wood and Bruce F. Wollenberg, "Power Generation, Operation, and Control," Wiley India Edition.
[R2]	Dr. K. Uma Rao, "Power System Operation and Control," Wiley India
[R3]	Prabha Kundur, "Power System Stability and Control," Tata McGraw's Hill
[R4]	M. Gopal, Modern Control Systems Theory, Second Edition, New Age International (P) Limited, Publishers
[R5]	"Electrical Power System Handbook", IEEE Press
Online Resources :	
[O1]	https://www.youtube.com/playlist?list=PL86E9AC8CFBA00ADB
[O2]	https://onlinecourses.nptel.ac.in/noc19_ee62/preview
Use of ICT Tools :	
Design of a compensator using MATLAB Design Tool.	
Contents beyond Syllabus :	
Phase Plane Analysis of a nonlinear system, Singular points, Observing Limit Cycles using MATLAB	
Extra Experiments :	
Introduction to MATLAB and Power System Toolbox	
Assignment Topics :	
Assignment 1 on FACTs Design Assignment 2 on ELDC analysis	

****

ADVANCED CONTROL SYSTEMS

Course Name : Advanced Control System (2019 PAT) **Course Number : 403142**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits :** **Theory : 03** **Oral : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral : 50 Marks**

Designation of the Course : Professional-Core

Prerequisites :

Control System – I Course at TE Elect
Matrix Algebra, Z-transform, and Laplace transform

Course Objectives:

1.	Introduce concepts of modern control theory, analysis, and design.
2.	Provide an overview of the digital control system and nonlinear control system.
3.	Explore advanced control techniques at an introductory level.

Course Outcomes:
At the end of the course, a graduate will be able to –

CO1.	**Design** a lag / lead compensator using Bode plot.	Create
CO2.	**Derive** describing function for ideal relay and **analyze** stability of nonlinear system .	Apply / Analyze
CO3.	**Obtain** state model of a dynamic system and **solve** the state equation.	Apply
CO4.	**Determine** controllability and observability of a system and **design** state feedback controller and state observer	Evaluate / Create
CO5.	**Describe** sampling and signal reconstruction and **analyze** stability of a digital control system.	Understand / Analyze
CO6.	**Explain** sliding mode control and adaptive control.	Understand

Course Contents :

Unit 1 :	**Compensator Design in Frequency Domain**	**[6 Hrs]**
Approach to control system design, cascade compensation networks, phase-lead and phase-lag compensator designs using bode plot, physical realization of compensators.		
Practical:	• Simulation of a lag compensator for a given system and comparison of compensated and uncompensated systems responses.	
Unit 2 :	**Nonlinear Control Systems**	**[6 Hrs]**
Introduction to nonlinear systems, common nonlinearities, describing function method, describing function of an ideal relay, stability analysis with describing function, introduction to Lyapunov stability analysis (basic concepts, definitions, and stability theorem)		
Practical:	• Simulation of the closed-loop system with ideal real as a nonlinearity.	
Unit 3 :	**Introduction to State-Space**	**[6 Hrs]**
Concept of state, state-space representation of dynamical systems in physical variable form, phase variable forms and Jordon / diagonal canonical form, conversion of the transfer function to state-space model and vice versa, state equation and its solution, state transition matrix and its properties, computation of state transition matrix by Laplace transform and Caley Hamilton method.		
Practical:	• Software program for determining a state-space model for a given transfer function and vice versa. • Software program for determining the state transition matrix.	

Unit 4 :	**State-Space Design**	**[6 Hrs]**
The concept of controllability and observability, Kalman's and Gilbert's tests for controllability and observability, effect of pole-zero cancellation, duality property, control system design using pole-placement using transformation matrix, direct substitution, and Ackermann's formula, State observers, design of a fullorder observer.		
Practical :	• Software program for checking the observability and controllability of a given system. • Simulation of state feedback control design using software. • Simulation of a full-order observer-based state feedback control system.	
Unit 5 :	**Introduction to Digital Control System**	**[6 Hrs]**
Basic block diagram of the digital control system, sampling and reconstruction, Shannon's Sampling theorem, zero-order hold and its transfer function, First-order hold (no derivation), characteristics equation, mapping between s-plane and z-plane, stability analysis in z-plane.		
Practical :	• Effect of sampling and verification of sampling theorem by simulation.	
Unit 6 :	**Advanced control system topics**	**[6 Hrs]**
Concept of sliding mode control, equivalent control, chattering, sliding mode control based on reaching law, Introduction to adaptive control, adaptive schemes, and control problems Optimal control-linear quadratic regulator problem.		
Practical :	-	

Text Books:

[T1]	Norman S. Nise, Control System Engineering, Sixth Edition, John Wily and Sons, Inc. 2011.
[T2]	Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Twelfth Edition, Pearson Education.
[T3]	Benjamin C. Kuo, Digital Control System, Second Edition, Oxford University Press, 2003.
[T4]	I. J. Nagarath, M. Gopal, Control System Engineering, Fourth Edition, New Age International (P) Limited, Publishers
[T5]	A. Nagoor Kani, Advanced Control Theory, Third Edition, CBS Publishers and Distributes, 2020.

Reference Books:

[R1]	Katsuhiko Ogata, Modern Control Engineering, Fifth Edition, Prentice-Hall, 2010.
[R2]	M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill.
[R3]	K. Ogata, Discrete-Time Control System, Second Edition, PHI Pvt. Ltd. 2006
[R4]	M. Gopal, Modern Control Systems Theory, Second Edition, New Age International (P) Limited, Publishers
[R5]	Karl J. Åström, Björn Wittenmark, Adaptive Control, Second Edition, Dover Publications, Inc. New Yark
[R6]	C Edwards, Sarah K. Spurgeon, S Spurgeon, Sliding Mode Control: Theory And Applications, Taylor and Francis, 1998
[R7]	Jean-Jacques E. Slotine, Jean-Jacques E.. Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall, 1991.

Online Resources :

[O1]	https://nptel.ac.in/courses/108102043
[O2]	https://nptel.ac.in/courses/108102113

Self-Learning Topics :
• Properties and theorems related to Z Transform • Properties of STM • Numerical on Observer Design using various methods.
Use of ICT Tools :
• Design of a compensator using MATLAB SISO Design Tool. • Introduction to Scilab for Control System thorough Spoken Tutorial ICT tool
Contents beyond Syllabus :
Phase Plane Analysis of a non linear system, Singular points, Observing Limit Cycles using MATLAB
Extra Experiments :
• Introduction to MATLAB and Control System Toolbox
Assignment Topics :
Assignment 1 on Compensator Design Assignment 2 on Describing Function analysis Assignment 3 on State Space Representation and solution of state equation Assignment 4 on Pole placement through state feedback and observer design Assignment 5 on Digital

****

PLC and SCADA

Course Name : Elective I - PLC and SCADA 2019 Course **Course Number : 403143A**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**		**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Oral : 25 Marks**

Designation of the Course : Professional-Core

Prerequisites : Logic gates operations, Boolean algebra, Relay Logic

Course Objectives :

1.	To make the students understand the fundamentals of automation and various automation systems used in the industry, such as PLC.
2.	To provide knowledge levels needed for PLC programming and operating.
3.	To develop the architecture of SCADA, explaining each unit in detail.
4.	To apply knowledge gained about PLCs and SCADA systems to real-life industrial applications

Course Outcomes :
At the end of the course, a graduate will be able to –

C403A.1	Develop and explain the working of a PLC with the help of a block diagram
C403A.2	Classify input and output interfacing devices with PLC.
C403A.3	Design PLC based application by proper selection criteria, developing GUI and ladder program
C403A.4	Execute, debug, and test the programs developed for digital and analog operations
C403A.5	Develop the architecture of SCADA and explain the importance of SCADA in critical infrastructure
C403A.6	Describe the SCADA protocols and digital control systems, along with their architecture for automation

Course Contents :

Unit 1 :	**Introduction to PLC**	**[7 Hrs]**

Role of automation in Industries, benefits of automation, Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers' Association), types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces), CPU, programmers and monitors, power supplies, selection criterion, advantages and disadvantages, specifications, comparison of various PLCs manufactured by Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.

PR:

Unit 2 :	**Interfacing of PLC with I/O devices**	**[8 Hrs]**

Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices Sensors-temperature, pressure, flow, level Actuators-Electrical, pneumatic, hydraulic Encoders-Incremental, Absolute Transducers, Limit switches, proximity sensors Control Elements-Mechanical, Electrical, Fluid valves

PR :
1. Interfacing of lamp & button with PLC for ON & OFF operation. Verify all logic gates.
2. Set / Reset operation: one push button for ON & other push button for OFF operation.

Unit 3 :	**Programming of PLC**	**[8 Hrs]**
Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of ladder diagram Timer and counter- types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller.		
PR:	1. Performed delayed operation of lamp by using push button. 2. UP/DOWN counter with RESET instruction. 3. Combination of counter & timer for lamp ON/OFF operation.	
Unit 4 :	**Advance function and Applications of PLC**	**[8 Hrs]**
Analog PLC operation and PLC analog signal processing, PID principles, Typical continuous process control curves, simple closed loop systems, closed loop system using Proportional, Integral and Derivative (PID), PID modules, PID tuning, tuning methods including "Adjust and observe" method. Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive. PLC Applications in developing systems- Tank level controller using analog signals, temperature controller using RTD, speed control of electric motor.		
PR :	1. PLC based temperature sensing using RTD. 2. PLC based thermal ON/OFF control.	
Unit 5 :	**SCADA Systems**	**[7 Hrs]**
Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, important definitions HMI, MTU, RTU, communication means, Desirable Properties of SCADA system, advantages, disadvantages and applications of SCADA. SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS), System operating states, SCADA system in critical infrastructure: Petroleum Refining Process, Conventional electric power generation, Water Purification System, Chemical Plant.		
PR:	1. PLC interfaced with SCADA & status read/command transfer operation. 2. Parameter reading of PLC in SCADA. 3. Alarm annunciation using SCADA. 4. Reporting & trending in SCADA system 5. Temperature monitoring by using SCADA.	
Unit 6 :	**SCADA Protocols and Distributed Control Systems**	**[7 Hrs]**
Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus). Distributed Control System: Introduction to DCS- its working & operation, Architecture , Features, Advantages & Applications of DCS, Comparison between DCS & PLC		
PR :		
Text Books :		
[T1]	John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi, 5th Edition	

[T2]	John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications", PHI Publishers
[T3]	Ronald L. Krutz, "Securing SCADA System", Wiley Publishing
[T4]	Stuart A Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised edition
[T5]	Sunil S. Rao, "Switchgear and Protections", Khanna Publication
[T6]	Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition
[T7]	Curtis Johnson, "Process Control Instrumentation Technology", Prentice Hall of India
Reference Books :	
[R1]	Gordan Clark, Deem Reynders, "Practical Modern SCADA Protocols", ELSEVIER
[R2]	Batten G. L., "Programmable Controllers", McGraw Hill Inc., Second Edition
[R3]	Bennett Stuart, "Real Time Computer Control", Prentice Hall, 1988
[R4]	Krishna Kant, "Computer Based Industrial Control", PHI
[R5]	P. K. Srivstava, "Programmable Logic Controllers with Applications", BPB Publications
[R6]	Distributed Computer Control systems in Industrial Automation, D Popovic & Vijay Bhatkar
Self-Learning Topics :	
Programming with PICOSOFT	
Contents beyond Syllabus :	
Hysteresis control using PLC and SCADA.	
Extra Experiments :	
1. Traffic light controller, Pump controller 2. ON/OFF control using Hysteresis.	
Bridging Courses :	
1.Introduction to Micrologix 1400 2.Introduction to SCADA software Factory Talk View	
Assignment Topics :	
Sample question are included 1. Explain block diagram of PLC, Advantages & disadvantages, Applications 2. Draw and explain architecture of SCADA, Advantages & disadvantages, Applications	
Presentations :	
1. Logic gates, Boolean algebra 2. Types of PLC 3. Timers 4. Counters	

Power Quality

Course Name Elective I - Power Quality **Course Number : 403143B**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week** **Tutorial : NA**	**Credits** **Th / Tut : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **OR : 25 Marks**

Designation of the Course : Professional-Elective

Prerequisites :

Fundamentals of Power system and Power electronics

Course Objectives :

1.	Develop understanding of power quality attributes.
2.	Make students describe problems associated with poor power quality.
3.	Make students describe mitigation techniques for improving power quality
4.	Learn various equipment of monitoring and assessment.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Understand power quality and attribute of power quality
CO2.	Describe voltage flicker and mitigation of it
CO3.	Analyze the effect of power system events on voltage sag and its characteristics
CO4.	Identify the sources of harmonics and harmonics produced
CO5.	Select proper method for harmonic mitigation along with methods of power quality monitoring
CO6.	Carry out power quality monitoring using power quality analyzers.

Course Contents :

Unit 1 : Basics of Power Quality [06 Hrs]

Importance of power quality, terms and definitions of power quality as per IEEE std. 1159-2019 such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding, grounding and power quality, recommended grounding practices for noise and power quality control.

Practical:

1. Study of the power quality analyzer and measurement of various power quality parameters.

Unit 2 : RMS Voltage variations, Flickers and Transient Over-Voltages [06 Hrs]

RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Ferro-resonance Various means to reduce flickers. Flicker meter and monitoring. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages.

Unit 3 :	**Voltage Sag, Swell and Interruption**	**[06 Hrs]**

Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag, Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of type of fault, fault location and fault level on voltage sag. Phase angle jumps. Types of sags (Type 1 to type 7). Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag limits for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Measurement of voltage sag half cycle RMS, one cycle rms methods. Representation of the results of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions.

Practical:

1. Measurement of voltage sag magnitude and duration by using digital storage oscilloscope/ power quality analyzer.

Unit 4 :	**Harmonics-I**	**[06 Hrs]**

Definition of harmonics, inter-harmonics, sub-harmonics. Causes and effects of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices and other indices for assessing impacts of harmonics. A.C. quantities under non-sinusoidal conditions. Triplen harmonics characteristics and non characteristics harmonics. Power assessment under waveform distortion conditions. Harmonic sources and harmonic generation from lighting loads, Computer and allied load including SMPS, household equipment, Office automation devices, Utility equipment like transformer, synchronous machines and FACTS devices. Industrial equipment – induction machines, AC and Dc drives, Arc Furnaces.

Practicals:

1. Measurement of harmonic distortion of various non linear loads
2. Harmonic analysis of SMPS based Equipment such as UPS /AC/DC drive.
3. Analysis of performance of induction motor/transformer operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter.
4. Harmonic compliance of institute as per IEEE 519-2014 standard and sizing of hybrid (Active + detuned filter).
5. Power quality audit of institute or department.
6. Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.)
7. Measurement of harmonic distortion of various Equipment's such as UPS /AC/DC drive
8. Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.)
9. Analysis of performance of induction motor/transformer operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter.

Unit 5 :	**Harmonics-II**	**[06 Hrs]**

Harmonics resonances - series and parallel resonances. Consequences of harmonic resonance. Principles for controlling harmonics. Reducing harmonic currents in loads. K-rated transformer. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Modifying the system frequency response. Harmonic filtering, IEEE 1531 standard for key design criteria for filters. Passive filters, Notch filter, Tuned filters, Broadband filters and active filters. IEEE Standard 519-2014 for Harmonic control.

Unit 6 :	**Power Quality Monitoring & Assessment**	**[06 Hrs]**

Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality instrumentation. Power quality analyser specification requirement as per EN50160 Standard. Selection of power quality equipment for cost effective power quality monitoring, Selection of power quality monitors, selection of monitoring location and period. Selection of transducers. Harmonic monitoring, Transient monitoring, event recording and flicker monitoring. Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion.

Practical:

1. Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonic measurement (THD) by using professional software like MATLAB.

Text Books :

[T1]	R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.
[T2]	M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions", New York: IEEE Press, 2000, Series on Power Engineering.
[T3]	C.Sankaran "Power quality", CRC Press
[T4]	Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons.

Reference Books :

[R1]	Enriques Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling and Analysis", John Wiley and Sons Ltd.
[R2]	Ewald F. Fuchs, Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines" Elsevier Publication.
[R3]	Arrillaga, M. R. Watson, "Power System Harmonics", John Wiley and Sons.
[R4]	G. J. Heydt, "Electric Power Quality", Stars in Circle Publications.
[R5]	EN50160 and IEEE 1100, 1346, 519, and 1159 standards

Guidelines for Instructor's Manual

Instructor's Manual shall have

1. Brief relevant theory
2. Equipment with specifications.
3. Connection diagram/ methodology.
4. Format of observation table and sample results.

Guidelines for Student's Lab Journal

The Student's Lab Journal should contain the following related to every experiment –

- Theory related to the experiment.
- Apparatus with their detailed specifications.
- Connection diagram or circuit diagram.
- Observation table/simulation waveforms.
- Sample calculations for one or two readings.
- Result table.
- Graph and conclusions
- Few short questions related to the experiment.

Guidelines for Laboratory conduction

- Read and understand the power quality analyzer manual completely.
- Make sure that connections of the power analyzer are done as per manual.
- Follow safety protocols while doing a power quality audit

Self-Learning Topics :

Active Filter, Sizing and location of active filters, Advantages of active filters over passive filters, Hybrid filters, Selection of power quality equipment's for cost effective power quality monitoring, selection of voltage and current transducers. Power quality indices

Assignment Topics :

1. Basics of power quality
2. Voltage sag & Transients, Flickers
3. Fundamentals of Harmonics and Harmonic mitigation techniques
4. Power quality monitoring

****

Alternate Energy System

Course Name : Alternate Energy System **Course Number : 403144A**		
Credits **Th : 03** **Tut : 01**	**Credits** **Th : 03** **Tut : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Term Work : 25 Marks**
Type of the Course : Professional-Core		
Prerequisites :		
• Basic knowledge of solar thermal and solar photovoltaic systems.		
• Basic knowledge of wind energy, biomass energy, fuel cell and storage systems.		
Course Objectives :		
Develop a fundamental understanding of solar thermal and solar photovoltaic systems.		
Provide the knowledge of development and operation of wind energy system		
Discuss bio-energy resource assessment.		
Introduce different storage systems, Integration and Economics of Renewable Energy Systems.		
Course Outcomes : **At the end of the course, a graduate will be able to –**		
Analyze the performance of solar thermal and photovoltaic systems.		
Determine wind turbine performance.		
Explain and evaluate biomass resources in an Indian context.		
Illustrate the importance of storage systems.		
Analyze the economics of renewable energy sources.		
Course Contents :		
Solar Energy-I		
Solar radiation at the earth's surface, Solar constant, Spectral distribution, Extraterrestrial Radiation, Solar Terrestrial Radiation, Solar radiation geometry, Computation of cosθ for any location having any orientation, Empirical equations for predicting the availability of solar radiation: Monthly average daily and hourly global and diffuse radiation, Beam and Diffuse radiation under cloudless skies, Solar radiation on tilted surfaces : a)Beam radiation, b)Diffuse radiation, c)Reflected radiation, d)Flux on tilted surface. Instruments for measuring solar radiation, Devices for thermal collection and storage, Thermal applications, Introduction to concentrating solar power (CSP) plants using technologies like a) Parabolic troughs b) Linear Fresnel reflector, c) Parabolic Dish, etc.		
Solar Energy-II		
Introduction to family of solar film technology, Single c-Si, Poly c-Si PV Cell, Module and Array, Array Design (factors influencing the electrical design of the solar array) : a) Sun Intensity, b)Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate, f) Electrical Load Matching, g) Sun Tracking, Peak Power Point Operation, Electrical characteristics of Silicon PV Cells and Modules, PV System Components, Efficiency of PV system, MPPT of solar system, PV system design for various applications(residential, commercial and industrial)		

Introduction to family of solar film technology, Single c-Si, Poly c-Si PV Cell, Module and Array, Array Design (factors influencing the electrical design of the solar array) : a) Sun Intensity, b)Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate, f) Electrical Load Matching, g) Sun Tracking, Peak Power Point Operation, Electrical characteristics of Silicon PV Cells and Modules, PV System Components, Efficiency of PV system, MPPT of solar system, PV system design for various applications(residential, commercial and industrial)		
Unit 3 :	**Wind Energy**	**[8 Hrs]**
Power Contained in Wind, Thermodynamics of Wind Energy, Efficiency Limit for Wind Energy Conversion, the maximum energy obtained for a Thrust-operated converter (Efficiency limit), Design of Wind Turbine Rotor, Power-Speed Characteristics, Torque-Speed Characteristics, Wind Turbine Control Systems: a) Pitch Angle Control, b) Stall Control, c) Power Electronics Control, d) Yaw Control, Control Strategy, Wind Speed Statistics, Statistical Wind Speed Distributions, Site and Turbine Selection, Extraction of wind energy and wind turbine power. Introduction to Offshore Wind Energy System and its comparison with Wind Energy System.		
Unit 4 :	**Biomass Energy**	**[6 Hrs]**
Biomass Classification, Biomass Resources and their Energy Potential, Biomass Conversion Technologies: Anaerobic Digestion, Ethanol Fermentation, Biomass Gasification: Gasifiers, Fluidized Bed Gasifier, Biogas Technologies and their factor affecting Biogas Production, Biogas Plants: Floating and Fixed Dome type, designing of biogas plant, Introduction to Biodiesel**,** Power Generation from Municipal Solid Waste (MSW), Landfill Gas, Liquid Waste.		
Unit 5 :	**Fuel Cells and Storage Systems**	**[8 Hrs]**
A. Fuel Cells: Operating principles of Fuel Cell, Fuel and Oxidant Consumption, Fuel Cell System Characteristics, Introduction to Fuel Cell Technology and its type, application and limits. **B. Storage systems:** Hydrogen storage: Hydrogen production, relevant properties, Hydrogen as an Engine Fuel, methods of Hydrogen storage. Batteries: Introduction to Batteries, Elements of Electro-Chemical Cell, Battery classification, Battery Parameters, Factors affecting battery performance. Introduction to other storage technologies: pump storage, SMES, compressed air storage.		
Unit 6 :	**Integration of RES**	**[6 Hrs]**
A. Integration of RES with grid, Grid codes. B. Economics of RES: Simple, Initial rate of return, time value, Net present value, Internal rate of return, Life cycle costing, Effect of fuel Escalation, Annualized and levelized cost of energy.		
Text Books :		

[T1]	S.P. Sukhatme, "Solar Energy", Tata McGraw Hill
[T2]	Chetan Singh Solanki, "Solar Photovoltaics-Fundamentals, Technologies and Applications", PHI Second Edition
[T3]	Godfrey Boyle, "Renewable Energy", Third edition, Oxford University Press
[T4]	H. P. Garg, J. Prakash, "Solar Energy-Fundamentals and Applications", Tata McGraw hill Publishing Co. ltd., First Revised Edition.
[T5]	Mukund R. Patel, "Wind and Power Solar System", CRC Press
[T6]	Gilbert M. Masters, "Renewable and Efficient Electrical Power Systems", Wiley - IEEE Press, August 2004

Reference Books :	
[R1]	D.P.Kothari, K.C.Singal, Rakesh Rajan,"Renewable Energy Sources and Emerging Technologies", PHI Second Edition
[R2]	Tapan Bhattacharya, "Terrestrial Solar Photovoltaics", Narosa Publishing House
[R3]	Paul Gipe, "Wind Energy Comes of Age", John Wiley & Sons Inc.
[R4]	Donald L.Klass, "Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier, Academic Press
[R5]	Thomas Ackermann, "Wind Power in Power Systems", Wiley Publications.
[R6]	B T.Nijaguna, "Biogas Technology", New Age International Publishers.
[R7]	Tony Burton, Nick Jenkins, David Sharpe, "Wind Energy HandBook-Second Edition", John Wiley & Sons, Ltd., Publication
Online Resources:	
[O1]	A review on non-edible oil as a potential feedstock for biodiesel: physicochemical properties and production technologies.
[O2]	Fabrication and Design of Solar cooker.

List of Tutorials :

- Report on Renewable Energy Scenario in India/ across the Globe.
- Designing of standalone Solar PV systems for various loads (2 numericals).
- Report on analysis of Indian solar radiation data/ Wind data.
- Performance analysis of concentrating solar collector/ solar cooker/ solar air heaters
- Study of Wind Electric Generators with Grid Integration.
- Performance of Wind generation (2 or 3 numericals).
- Design of a community biogas plant for a village in India (1 or 2 numericals).
- Analysis of Non Edible oil as an alternate energy source.
- Performance of storage devices (3/4 numericals).
- Economics of renewable energy sources (2 or 3 numericals).
- Design of Hybrid system using HOMER demo software

Contents beyond Syllabus:

- Maharashtra state renewable Scenario
- Indian Renewable Energy status and scenario.

Bridging Courses:

- Industrial Visit to Biogas Plant used to generate power.

Self-study Contents:

- Design of PV system for own home.
- Explain classification of batteries, Battery Parameters and factors affecting battery performance.

Assignment Topics :

- Explain concentrating solar power (CSP) plants using technologies like a) Parabolic troughs b) Linear Fresnel reflector, c) Paraboloid Dish.
- Explain maximum power point tracking (MPPT) of solar system.
- Explain offshore Wind Energy System and its advantages over other wind Energy systems
- Explain a) Anaerobic Digestion b) Ethanol Fermentation; based biomass based conversion technologies.
- Explain Fuel Cell Technology and its type, application and limits.
- Explain with suitable example concept of annualized and levelized cost of energy

****

Electric and Hybrid Vehicle

403144B: Elective II - Electric and Hybrid Vehicle						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hrs/Week	Theory	03	ISE	30
Tutorial	02	Hrs/Week/Batch	Tutorial	01	ESE	70
					Term work	25

Course Objectives:

This course aims to:
1. To gain knowledge of Li-ion battery protection.
2. To learn HEV Subsystems and Configurations.
3. To understand Mathematical Model of Li-ion battery.
4. To familiarize with Hybridization of drivetrains.
5. To learn Star Labeling Schemes for Li-ion Packs.

Course Outcomes:

At the end of this course, students will be able to:
CO1: Analyze the Life Cycle Assessment of Li-ion battery.
CO2 : Describe the different types of Li-ion charging methods
CO3 : Comprehend the knowledge of drivetrain hybridization.
CO4 : Evaluate EV motor sizing.
CO5 : Classify Battery Recycling methods.

Unit 01	**Li-ion Battery**	**07 hrs**

Materials used for Li-ion battery, Nanostructured Electrode Materials for Li-Ion Batteries, Li-ion battery protection, Wireless charging of EV, Life Cycle Assessment of Li-ion battery, Solid-state Battery, Panasonic 18650 & 2170 cell

Unit 02	**Battery Charging and Modelling**	**07 hrs**

TSCC/CV charging and CVCC/CC charging of Li-Ion battery, BMS standards, SoC Estimation methods (Kalman Filter, Neural Network, Fuzzy logic), Public EV charging stations, Solar Powered Charging Stations, Modeling of Lithium-ion batteries, Thermal Modeling of Li-ion battery.

Unit 03	**Electric Vehicle Technologies**	**07 hrs**

Battery Swapping System, EV Fleet Management, Sensors for Electric Vehicles Electric bus, Electric trucks, Fuel cell vehicles, Introduction of EV Subsystems and Configurations, Energy management strategies and its general architecture

Unit 04	**Plug-In Hybrid Electric Vehicles**	**07 hrs**

Hybridization of drivetrains in HEVs, Hybridization of energy sources in EVs, Power Flow control in hybrid drive train topologies, Power Management Strategies in HEV, Introduction of HEV Subsystems and Configurations, Vehicle Dynamics Fundamentals and HEV Modeling (Series Hybrid), Fuel efficiency analysis

Unit 05	**EV Components Design**	**07 hrs**

Criteria for battery selection , Forces on EV calculation, Power for EV calculation, Sizing the Power Converter, Sizing of Electric Machine for EVs and HEVs, Motor Torque Calculation, Induction motor control, PMSM motor control, Battery pack design, In vehicle networks- CAN

Unit 06	**Electric Vehicle Policies and Startups**	**07 hrs**

FAME-II Policy , Charging Infrastructure for Electric Vehicles - Revised Guidelines and Standards , Star Labeling Schemes for Li-ion Packs- BEE India, EV Tariff, EV Startup examples, Li-ion Battery Recycling Policy and Standards

Text Books:	
[T1]	Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau
[T2]	Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011
[T3]	Electric and Hybrid Vehicles by Tom Denton
Reference Books:	
[R1]	Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010
[R2]	James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
Online Resources:	
[O1]	NPTEL Course : Electric Vehicles - Part 1 by Prof. Amit

List of Tutorials:

Any 8 of the following

1. Introduction to battery modeling MATLAB Simulink
2. Introduction to BLDC motor control MATLAB Simulink
3. Introduction to Induction Motor control MATLAB Simulink
4. Power Converter selection in MATLAB Simulink
5. Study of EV subsidies in different states.
6. Visit to the Electric Vehicle Charging Station.
7. Study of Thermal Modeling in Ansys software
8. Study of Harmonics issues of EV charging.
9. Fuel efficiency evaluation of a series HEV in city and high-way.
10. Various strategies for improving vehicle energy/fuel efficiency regenerating braking.
11. Study of various Battery Recycling Methods.

Guidelines for Assessment of Tutorial:

- Maintain Record in file or separate notebook.
- Timely submission of tutorials.
- Assessment of the report must be based on understanding, presentation and contents.

****

Project Stage-I

Course Name : Project Stage-I 2019 Course **Course Number : 403145**		
Teaching Scheme **Tutorial : 4 Hrs. / week**		**Examination Scheme [Marks]** **Oral : 50 Marks** **Term Work : 50 Marks**
Designation of the Course : Professional-Core		
Prerequisites : All subjects		

Course Objectives :

1.	Provide an opportunity to learn new software, interdisciplinary theory, concepts, technology, etc. not covered in earlier subjects.
2.	Empower students to use engineering knowledge and skills learned in previous courses to deliver a product that has passed through the design, analysis, testing, and evaluation.
3.	Encourage multidisciplinary project work through the integration of knowledge.
4.	Allow students to develop problem-solving, analysis, synthesis, and evaluation skills.
5.	Encourage teamwork.
6.	Improve students' communication skills by asking them to produce both a professional report and to give an oral presentation.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1	Define the project problem statement and identify the scope of the project.
CO2	Search the appropriate research papers, standards and e-resources and write a literature survey.
CO3	Identify tools, techniques, methods, concepts, measuring devices, and instruments required for the project to define the methodology of the project.
CO4	Justify the selection of electrical, electronic and mechanical components for the project prototyping.
CO5	Simulate or develop a system for software or hardware verification.
CO6	Write a project report with proper interpretation of results.

Course Contents :

Guidelines for students:
1. Form a group of 3-4 students.
2. Select a project problem statement based on an industrial or societal issue and ideate on it.
3. Research on the project topic through existing theories, literature, technology, patents, etc.
4. Define objectives, scope, and outcomes of the project in the 1st presentation.
5. Maintain a notebook to keep records of all the meetings, discussions, notes, etc. This is to be done by the individual student.
6. Some of the parameters mentioned in the above table will be evaluated and assessed at the group
7. Student should maintain Project Work Book.

Term work evaluation guidelines are given below as mentioned in syllabus.

Semester I

Sr. No.	Activity	Deadline (Semester I)	Parameters for Evaluation
1.	Topic Approval Presentations	Up to 3rd Week	● Problem definition clearly stated (YES/NO) ● Objectives clearly defined (YES/NO)

			● The overall project idea is feasible (YES/NO)
2.	Progress Review-1 Presentation	Up to 8th Week	● Problem Definition (5) ● Scope & Objectives (10) ● Literature Review (10) ● Methodology (10) ● Block Diagram / Architecture (10) ● Project Planning (5) **Total Marks (50)**
3.	Progress Review-2 Presentation	Up to 12th Week	● Requirement Specification (10) ● Literature Review (revised) (5) ● Detailed Design (10) ● Experimental Setup/Simulation (10) ● Performance Parameters (10) ● Partial Conclusion (5) **Total Marks (50)**
4.	Submission of Project Stage –I Report	Up to 14th Week	● Timely submission (5) ● Formatting and Report Writing Style (5) ● Abstract, Literature Survey, Conclusion (5) ● Refereed References (5) ● Grammatical correctness in the report (5) **Total Marks (25)** **(Review 1+ Review 2) conversion to 25 marks +Report (25 marks) = 50 Marks**

****

MOOCs

Course Name : MOOCs 2019 Course		**Course Number : 403146**
Teaching Scheme **Tutorial : - Hrs. / week**		**Examination Scheme [Marks]** **Term Work : 50 Marks**
Designation of the Course : Professional-Core		
Prerequisites : All subjects		
Course Objectives :		
1.	Provide an opportunity to learn new software, interdisciplinary theory, concepts, technology, etc. not covered in earlier subjects.	
2.	Make students employable in the industry or pursue a suitable higher education program.	
3.	Exposure to relevant tools and technologies.	
4.	Enrich the learning experience by using audio video and multimedia and state of the are pedagogy.	
Course Outcomes : At the end of the course, a graduate will be able to –		
CO1	Enables the students to directly engage and learn from the best faculty in the country in order to strengthen the fundamentals.	
CO2	Explore new areas of interest in a relevant field.	
CO3	Enable self learning initiative in learners.	
CO4	Develop critical thinking to solve complex problems in engineering, science and humanities.	
CO5	Improve communication skills by interacting with peers and course teachers.	
Course Contents :		

Guidelines for students:

1. Students have to register on the SWAYAM portal.
2. Through the SWAYAM portal, explore the courses available by NPTEL coordinator.
3. The minimum duration of the NPTEL course to be registered by the students has to be 8/12 weeks. (as per the course offered in the semester.)
4. Students can register the courses of engineering, science, humanities, management, and multidisciplinary in the NPTEL portal.
5. Students have to submit the assignments as per schedule given by NPTEL course structure and take part in a self assessment test.
6. Students have to register for the certificate examination of NPTEL by paying the required fees.
7. Students will be awarded credits of MOOCs only when they earn the certificate of the registered course.
8. Students have to submit proof (certificate) to the department in order to get credits.

Guidelines for institute:

1. It is advised that the institute should register for the NPTEL local chapter.
2. Keep the track of student registration in SWAYAM-NPTEL course.
3. Check the certificate authenticity submitted by student through online portal

Guidelines for Assessment:

1. The NPTEL will give percentage grades in certificates out of 100.
2. The percentage obtained needs to be converted to 50 marks and submitted as term work marks to university. (if someone got 75% marks then TW calculation will be 75/2=37.5=38 (out of 50) and round up the nearest integer.)
3. External examiner appointed by the university will assess certificates and marks obtained physically at the institute.

****

Engineering Economics-I

Course Name : Audit Course – VII - Engineering Economics-I **Course Number : 403147B**		
Teaching Scheme **Theory : 2 Hrs. / week**	**Credits** **Nil**	**Examination Scheme [Marks]** **In Sem: -** **End Sem : -**
Type of the Course :		

Course Objectives :

1.	Describe basics of economics and its application in engineering.
2.	Explain the concept of Time value of Money and Cash flow

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1	Discuss concepts related to business and its impact on enterprise.
CO2	Illustrate time value of money in economic analysis.

Course Contents :

Unit 1 :	**Engineering Economics**	**[10 Hrs]**

Nature and scope, General concepts on micro & macro economics. The Theory of demand, Demand function, Law of demand and its exceptions, Elasticity of demand, Law of supply and elasticity of supply. Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics – Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis – V ratio, Elementary economic Analysis – Material selection for product, Design selection for a product, Process planning.

Unit 2 :	**Time Value of Money and Cash flow analysis**	**[10 Hrs]**

Time value of money: Simple and compound interest, Nominal Interest rate, Effective Interest rate, Principle of economic equivalence. Cash Flow – Diagrams, Categories & Computation Depreciation: Meaning Causes, Factors affecting depreciation, Methods of providing depreciation, Straight Line Method & Diminishing Balance Method

Text Books :

[T1]	Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India.
[T2]	D.M. Mithani, Principles of Economics. Himalaya Publishing House

Reference Books :

[R1]	Sasmita Mishra, "Engineering Economics & Costing ", PHI
[R2]	Sullivan and Wicks, " Engineering Economy", Pearson
[R3]	R. Paneer Seelvan, " Engineering Economics", PHI

****

Switchgear and Protection

Course Name : Switchgear and Protection **Course Number : 403148**		
Teaching Scheme **Theory : 3Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral: 50 Marks** **Term Work : 25 Marks**

Type of the Course : Professional-Core

Prerequisites :

- Different type of faults in power system
- Various switchgears & their use in substation
- Principle and working of rotating machines and transformer with vector groups.

Course Objectives :

1.	Acquaint about construction and working principle of different types of HVCBs
2.	Elaborate the Need of protective Relaying and operating principles of different types of relays.
3.	Explain different type of faults in transformer, alternator and 3 phase Induction motor and various protective schemes related to them.
4.	Impart knowledge about transmission line protection schemes and characteristics of different types of distance relays

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1	Acquire the knowledge of fundamentals of protective relaying.
CO2	Derive expression for restriking voltage & RRRV in circuit breakers.
CO3	Explain construction & working principle of different high voltage circuit breakers.
CO4	Classify different types of relays and describe construction & working principle of them.
CO5	Describe various protection schemes used for power transformer, alternator, & induction motor.
CO6	Demonstrate transmission line protection schemes and testing of LV switchgears.

Course Contents :

Unit 1 :	**Fundamentals of protective relaying**	**[8 Hrs]**

Need for protective system, nature & causes of fault, types of faults, effects of faults, evolution of protective relaying, classification of relays, zones of protection, primary & backup protection, essential qualities of protective relaying. Trip circuit of circuit breaker, zone of protection. Various basic operating principles of protection- over current, (current graded & time graded),directional over current, differential, distance, induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numericals on TSM , PSM & operating time of relay

Unit 2 :	**Fundamentals of arc interruption:**	**[6 Hrs]**

Ionization of gases, deionization, Electric arc formation , Current interruption in AC circuit breaker, high & low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching, Numerical on RRRV, current chopping and resistance switching.

Unit 3 :	**Circuit Breaker**	**[5 Hrs]**
Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity – symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating). Classification of high voltage circuit breaker. Working and constructional features of ACB, SF6 VCB- advantages, disadvantages and applications. Auto reclosing. Testing of circuit breakers, Introduction to GIS, its advantages over conventional substation.		
Practicals :	• Study of switchgear testing kit. • Study of Fuse, MCB & testing of MCB • Study & testing of contactors. • Study & testing of MCCB. • Study & testing of ACB.	
Unit 4 :	**Static & Digital Relaying :**	**[3 Hrs]**
Overview of Static relay, block diagram, operating principal, merits & demerits of static relay. Numerical Relays:-Introduction, Block diagram of numerical relay, Sampling theorem, Anti –Aliasing Filter, Block diagram of PMU and its applications.		
Unit 5 :	**A) Power Transformer Protection**	**[3 Hrs]**
Types of faults in transformer. Percentage differential protection in transformers, Restricted E/F protection. Incipient faults, buchholz relay, protection against over fluxing. Protection against inrush current.		
	B) Three Phase Induction Motor Protection	**[2Hrs]**
Abnormal conditions & causes of failures in 3 phase Induction motor, single phasing protection, Overload protection, Short circuit protection.		
	C) Synchronous Generator (Alternator) Protection	**[3 Hrs]**
Various faults in Alternator, abnormal operating conditions- stator faults, longitudinal percentage differential scheme and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation, protection against loss of excitation using offset Mho relay, loss of prime mover.		
Practical :	• Study & testing of thermal overload relay for Induction Motor protection.	
Unit 6 :	**Transmission line Protection:**	**[6 Hrs]**
Over current protection for feeder using directional & non directional overcurrent relays, Introduction to distance protection, impedance relay, reactance relay, mho relay & Quadrilateral Relays, Introduction to PLCC, block diagram, advantages, disadvantages, three stepped distance protection, Effect of arc resistance, and power swing on performance of distance relay. Realization of distance relays (impedance, reactance, & mho relay) using numerical relaying algorithm (flowchart, block diagram), Introduction to Wide Area Measurement (WAM) system.		
Practicals :	• Protection of Transmission line using Impedance relay	
Text Books :		
[T1]	Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Co. Ltd.	
[T2]	Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India	
[T3]	Bhavesh Bhalja,R.P. Maheshwari, N.G. Chothani, "Protection and Switchgear", Oxford University Press, 2011 Edition.	
[T4]	J.B.Gupta "Switchgear and Protection", S.K. Kataria and Sons.	

[T5]	Oza, Nair, Mehta , Makwana "Power system protection & switchgear" , McGraw Hill Education
Reference Books :	
[R1]	S. Rao, "Switchgear Protection and Power Systems", Khanna Publications
[R2]	J Lewis Blackburn , "Protective Relaying- Principles and Applications", Dekker Publications.
[R3]	A.G. Phadke, J.S. Thorp ,Computer relaying for Power System , Research Studies Press LTD, England.(John Willy and Sons Inc New York)
[R4]	Mason C.R., "Art and Science of Protective Relaying", Wiley Eastern Limited.
[R5]	Arun Ingole, "Switchgear and Protection", Pearson.
Online Resources :	
[O1]	Prof. Dr S.A. Soman, IIT Mumbai, A Web course on "Digital Protection of power System" http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Protection/Course_home_L27.html
[O2]	NPTEL Course on Power System Protection and Switchgear

Extra Experiments :

- Study of different protection schemes for power transformer.
- Study of Vacuum Circuit Breaker.
- Study of bus-bar protection schemes.

Bridging Courses

Industrial Visit to 220 kV Substation to bridge the gap between theoretical knowledge and practical things.

Contents beyond Syllabus

- E/f & phase fault relay, different connections
- Drawbacks of overcurrent protection
- Choice between IDMT & DTOC

Assignment Topics :

- Numericals based on calculation of restriking voltage & RRRV, Explain the terms such as arc voltage, restriking voltage, recovery voltage, RRRV, Explain current chopping & resistance switching.
- Explain essential qualities of protective relaying, what is zone of protection , explain primary & back up protection, explain protection principles used in differential relay & distance relay
- Explain with neat diagram construction & working of ACB, SF6 & VCB, explain different rating of HV CB.
- Explain various protection schemes used for power transformer (eg from inrush current, incipient faults), various faults in alternator and its protection schemes (failure of prime mover, failure of excitation, & over speed protection)
- Explain static relay & numerical relay with neat block diagram , state its advantages & disadvantages over electromagnetic relay, Explain three step distance protection scheme for transmission lines

****

Advanced Electrical Drives and Control

Course Name : Advanced Electrical Drives and Control **Course Number : 403149**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs/Week** **Tutorial :**	Credits TH: 03 PR : 01	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Pract : 50 Marks** **Term work : 25 Marks**

Designation of the Course : Professional-Core

Prerequisites :

- Fundamentals of Electrical Machines - DC Machines. Induction Machines
- Power Electronic Circuits,
- Generalized Machine Theory

Fundamental of Electrical, Mechanical and Thermal engineering

Course Objectives :

1.	Understand motor load dynamics.
2.	Study and analyze the operation of the converter fed and chopper fed dc drives
3.	Study and understand braking methods of D.C. and Induction motor drive
4.	Study vector control of induction motors
5.	Study synchronous and BLDC motor drive
6.	Study classes and duty of motor
7.	Understands the modes of operation of drive in various applications

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Explain motor load dynamics and multi quadrant operation of drives.
CO2.	Analyze operation of converter fed and chopper fed DC drives.
CO3.	Apply different braking methods of D.C. and induction motor drive.
CO4.	Elaborate vector control for induction motor and BLDC drives.
CO5.	Elaborate synchronous motor, reluctance motor drive
CO6.	Differentiate between classes and duty cycles of motors and select suitable drives in various industrial applications.

Course Contents :

Unit 1 :	Electrical Drives	**[7 Hrs]**

A. Definition, components of electric drive system, types of electrical drives (DC and AC), selection of drive parameters, List of Industrial Applications

B. Motor-Load dynamics, speed-torque conventions and multi-quadrant operation, equivalent values of drive parameters, load torque components, nature and classification of load, constant power operation of a drive, steady-state stability.

Unit 2 :	DC Motor Drives:	**8 Hrs]**

A. Single-phase and three-phase fully controlled converter drives and performance of converter fed separately excited DC Motor for speed control operations, 12 pulse converter drives.

B. Chopper controlled drives for separately excited and series DC Motor operations. Closed-loop speed control of DC motor below and above base speed for starting, speed control and braking

PR/Tut :	1. Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).

	2. Speed control characteristics of single phase fully converter fed separately excited D.C. motor 3. Chopper fed D.C. series/separately motor speed control characteristics. 4. Speed control characteristics of 3-ph fully converter fed separately excited D.C. motor.	
Unit 3 :	Induction Motor Drives:	**[8 Hrs]**
Regenerative braking, dynamic braking, Plugging, Numerical based on braking and speed control, voltage source inverter (VSI) control, Steady State Analysis. Current source inverter (CSI) control-open and closed loop, Regenerative braking and multi quadrant operation of Induction motor drives, Principle of vector control, Block diagram of Vector control of induction motor, Failure modes of Drives.		
PR/Tut :	1. VSI fed 3 phase Induction motor (using V/f control PWM inverter) speed control characteristics 2. Electrical braking of 3 phases Induction Motor (DC Dynamic Braking, Plugging, Regenerative Braking). 3. Simulation of Induction Motor Vector Control. 4. Study of constant torque and constant power characteristic of induction motor.	
Unit 4 :	BLDC drive:	**[7 Hrs]**
Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics, closed loop control of BLDC drive (PI controller) , vector control of BLDC drive, Applications in EV (descriptive treatment)		
PR/Tut :	1. Study of speed control of BLDC / PMSM drive. 2. Simulation of closed loop control of BLDC / PMSM drive. 3. Simulation of vector control of PMSM/BLDC motor	
Unit 5 :	Synchronous Motor drives:	**[6 Hrs]**
A. PMSM Drive: Construction (Block diagram) and working for motoring and regenerative braking, Speed and torque Characteristics, closed loop control of PMSM drive (PI controller) , vector control of PMSM drive. B. Synchronous Reluctance Motor -Introduction, working of SRM , application in EV (descriptive treatment)		
PR/Tut :	1. Study of speed control of BLDC / PMSM drive. 2. Simulation of closed loop control of BLDC / PMSM drive. 3. Simulation of vector control of PMSM/BLDC motor	
Unit 6 :	Drive Application	**[6 Hrs]**
A. Classes of motor duty, types of enclosures for motor. B. Specific requirement and choice of drives for following applications: Machine tools , Textile mills, Steel rolling mills, Sugar mills, Traction drives, Crane and hoist drives, Solar and battery powered drives		
Text Books :		
[T1]	G. K. Dubey, "Fundamentals of Electric Drives", 2nd Edition, Narosa Publishing House	
[T2]	N. K. De, P. K. Sen, "Electric Drives", Prentice Hall of India Eastern Economy Edition	
[T3]	S. K. Pillai, "Analysis of Thyristor Power Conditioned Motors", University Press	
[T4]	G.K. Dubey, "Power Semiconductor controlled drives", PHI publication	
Reference Books :		
[R1]	R. Krishnan, "Electric Motor Drives – Modeling Analysis and Control", PHI India	
[R2]	B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education	
[R3]	V. Subrahmanyam, "Electric Drives: Concepts and Application", Tata Mc-Graw Hill (An imprint of Elsevier)	
[R4]	M.D. Singh and Khanchandani "Power Electronics", Tata Mc-Graw Hill	

[R5]	Austin Huges, "Electrical motor and drives: Fundamental, types and applications", Heinemann Newnes, London
[R6]	Tyagi MATLAB for engineers oxford (Indian Edition)
[R6]	Malcolm Barnes, "Practical Variable Speed Drives and Power Electronics", Elsevier Newnes Publications

Unit	Text Books	Reference Books
Unit 1	T1	R3
Unit 2	T1 T5	R2 R4
Unit 3	T1 T4	R1 R5
Unit 4	T1, T2, T5	R1, R2
Unit 5	T1, T3, T5	R1, R6
Unit 6	T1, T2	R3, R5, R7

List of Experiments

Total 9 experiments to be conducted from the following list of practical.

A) Following 5 experiments are compulsory (Hardware based)

1. Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).
2. Speed control characteristics of single phase fully converter fed separately excited D.C. motor
3. VSI fed 3 phase Induction motor (using V/f control PWM inverter) speed control characteristics.
4. Chopper fed D.C. series/separately motor speed control characteristics.
5. Electrical braking of 3 phases Induction Motor (DC Dynamic Braking, Plugging, Regenerative Braking).

B) Any 4 experiments from following (Hardware/software)

6. Speed control characteristics of 3-ph fully converter fed separately excited D.C. motor.
7. Simulation of Induction Motor Vector Control.
8. Study of constant torque and constant power characteristic of induction motor.
9. Study of speed control of BLDC / PMSM drive.
10. Simulation of closed loop control of BLDC / PMSM drive.
11. Simulation of vector control of PMSM/BLDC motor

Guidelines for Student's Lab Journal :

- Title, aim, circuit diagram, procedure and theory of power electronic switching device or converter circuit and expected machine performance with speed torque characteristics.
- Equipment along with the specifications needed to carry out the experiment.
- Circuit diagram, observation table, calculations must be written on the left side of the journal and aim, theory related to experiment and procedure must be written on the right side.
- Analyze and interpret the experimental results and write the conclusions appropriately.

Guidelines for Instructor's Manual :

Instructor's Manual shall have

- Title and circuit diagram of power electronic controlled drives/ electrical machine circuit. ·
- Working operation and output characteristics / output waveforms of power electronic switching device /converter circuit used to control the electric motor.
- Procedure to carry out the experiment

Guidelines for Lab /TW Assessment :

1. There should be continuous assessment for TW.
2. Assessment must be based on understanding level, attentiveness, presentation skills, efficiency and quality of report.
3. Timely submission of act.

Guidelines for Laboratory Conduction :

- Each group in the lab should have not more than three students. ·

● All the students in the group must do the connections and perform the practical under the guidance of the staff member. · ● Staff member has to check the results of all the groups.
Self-Learning Topics :
1. Thermal rating of Electrical Motors 2. Application of drives in Industry
Contents beyond Syllabus :
1 Fly wheel calculations 2 Switched reluctance machine
Extra Experiments :
1. Close loop control of PMSM motor hardware 2. AC dynamometer testing
Guest Lecture
Special drives like PMSM,/BLDC /Syn Reluctance Motor
Bridging Courses :
Revisions of Converters, Chopper and inverters NPTEL course of Power Electronically controlled Drives
Assignment Topics/Tutorial topics
• Steady state stability and Dc Drives • VSI and CSI fed IM • Construction and operation and Control of PMSM/BLDC • Selection of Drives for Industrial applications
Case Studies :
• Visit to process plant like sugar industry/ crushing mill / rolling mills

****

Smart Grid

Course Name : Elective III - Smart Grid (2019 PAT) **Course Number : 403150C**		
Teaching Scheme **Theory : 3 Hrs. / week**	**Credits :** **Theory : 03**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks**

Course Objectives:	
1.	Explain the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers.
2.	Describe the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home and Building Automation, Phase Shifting Transformers.
3.	Elaborate the concept of Substation Automation, Feeder Automation. Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, Phase Measurement Unit.
4.	Elaborate the concept of microgrid.

Course Outcomes: At the end of the course, a graduate will be able to –	
CO1.	Apply the knowledge to differentiate between Conventional and Smart Grid
CO2.	Describe importance of Supercapacitors
CO3.	Identify the need of Smart metering
CO4.	Apply the communication technology in smart grid.
CO5.	: Comprehend the issues of micro grid.

Course Contents :

Unit 1 :	Introduction to Smart Grid	**[7 Hrs]**
Concept of Smart Grid, Need of Smart Grid, Functions of Smart Grid, Opportunities and Barriers of Smart Grid, Drivers of SG in India, Functionalities and key components of smart grid, Difference between conventional and smart grid, Smart Grid Vision and Roadmap for India, Concept of Resilient and SelfHealing Grid, Smart Grid National Policies, Smart Cities, Pilot projects in India.		
Unit 2 :	Smart Grid Technologies	**[7 Hrs]**
Intelligent Electronic Devices (IED), Phase Measurement Unit (PMU). Smart Substations, Substation and Feeder Automation, application for monitoring, protection and control, Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid (V2G), Energy Storage Technologies and applications – Battery (flow and advanced), SMES, Super Capacitors, Compressed Air Energy Storage (CAES) and its comparison.		
Unit 3 :	Smart Meters and Advanced Metering Infrastructure	**[7 Hrs]**
Introduction to Smart Meters, Prepaid meters, Net Metering, Advanced Metering Infrastructure (AMI), Real Time Pricing, Automatic Meter Reading (AMR), Outage Management System (OMS), Smart Substation , IEC 61850, Smart Sensors, Geographic Information System (GIS), IS 16444, LowPAN RF meter.		
Unit 4 :	Communication Technology for Smart Grid	**[7 Hrs]**
Communication Architecture of SG, Wide Area Measurement Protection and Control (WAMPAC), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN)., ZigBee, GPS,		

Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing and Cyber Security for Smart Grid, LORaWAN, NB-IoT, SigFox.		
Unit 5 :	Microgrids	**[7 Hrs]**
Concept of Microgrid, need and applications of Microgrid, Microgrid Architecture, DC Microgrid, Hybrid Microgrid, Formation of Microgrid, Issues of interconnection, protection and control of Microgrid, Integration of renewable energy sources, Smart Microgrid, Microgrid and Smart Grid Comparison, Renewable Energy based Microgrid system.		
Unit 6 :	Power Quality issues and Challenges	**[7 Hrs]**
Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Smart Grid data analytics, Distributed Generation, Reliability Indices (CAIDI, CAIFI, MAIDI, MAIFI), Load Forecasting Methods, Smart Appliances, Home and Building Automation.		
Text Books:		
[T1]	Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response",CRC Press	
[T2]	Stuart Borlase, "Smart Grids-Infrastructure, Technology and Solutions", CRC Press, Taylor and Francis group	
[T3]	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley Publications.	
[T4]	Nikos Ziargyriour, "Micro grid, Architecture and Control", IEEE Press, Wiley Publications.	
Reference Books:		
[R1]	Yang Xiao, "Communication and Networking in Smart Grids", CRC Press, Taylor and Francis group	

****

Illumination Engineering

Course Name: Elective IV - Illumination Engineering **Course Number: 403151B**						
Teaching Scheme			**Credits**		**Examination Scheme**	
Theory	03	Hr/Week	**TH**	03	**ISE**	30 Marks
					ESE	70 Marks
Designation of the Course : Professional-Elective						
Course Objectives: The course aims :- 1. To explain conventional and modern lamps and their accessories. 2. To get detailed insight of indoor and outdoor illumination system components, control and designaspects. 3. To know the requirements of energy efficient lighting. 4. To introduce the modern trends in the lighting						
Course Outcomes: At the end of this course, student will be able to						
CO1	Define and reproduce various terms in illumination.					
CO2	Identify various parameters for illumination system design					
CO3	Design indoor and outdoor lighting systems.					
CO4	Enlist state of the art illumination systems.					
Course Contents:						
Unit 01	**Importance of Lighting in Human Life**					**07 hrs**
Optical systems of human eye, Dependence of human activities on light, performance characteristics of human visual system, External factors of vision-visual acuity, contrast, sensitivity, time illuminance, colour,visual perception, optical radiation hazards, Good and bad effects of lighting and perfect level of illumination, Artificial lighting as substitute to natural light, Ability to control natural light, Production of light, physics of generation of light, Properties of light, Quantification and Measurement of light.						
Unit 02	Light Sources and Electrical Control of Light Sources					**08 hrs**
Light Sources- Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals. Discharge Lamps: Theory of gas Discharge phenomena, lamp design considerations, characteristicsof low and high pressure mercury and Sodium vapour lamps, Low Vapour Pressure discharge lamps - Mercury Vapour lamp, Fluorescent Lamp, Compact Fluorescent Lamp (CFL) High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metalhalide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps, Induction lamps. Ballast, ignitors and dimmers for different types of lamps **Control of Light Sources** Photometric Control of Light Sources and their Quantification: Types of Luminaries, factors to be considered for designing luminaries Types of lighting fixtures. Optical control schemes, design procedure of reflecting and refracting type of luminaries. Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lighting fixtures according to installation type, types of lighting fixtures according to photometric usages, luminaries standard (IEC-598-Part I).						
Unit 03	Design Considerations for illumination schemes					**07 hrs**

Zonal cavity method for general lighting design, determination for zonal cavities and different shaped ceilings using COU (coefficient of utilization), beam angles and polar diagrams. Factors to be considered for design of indoor illumination scheme		
Unit 04	**Design of lighting schemes-I**	**07 hrs**
Indoor illumination design for following installations Residential (Numerical) Educational institute Commercial installation Hospitals Industrial lighting Special purpose lighting schemes Decorative lighting Theatre lighting Aquarium, swimming pool lighting		
Unit 05	**Design of lighting schemes-II**	**07 hrs**
Factors to be considered for design of outdoor illumination scheme Outdoor Lighting Design: Road classifications according to BIS, pole arrangement, terminology, lamp and luminaries' selection, different design procedures, beam lumen method,point by point method, isolux diagram, problems on point by point method. Outdoor illumination design for following installations: Road lighting (Numerical) Flood lighting (Numerical) Stadium and sports complex Lighting for advertisement/hoardings		
Unit 06	**Modern trends in illumination**	**07 hrs**
LED luminary designs Intelligent LED fixtures Natural light conduiting Organic lighting system LASERS, characteristics, features and applications, non-lighting lampsOptical fiber, its construction as a light guide, features and applications		
Text Books:		
[T1]	H. S. Mamak, "Book on Lighting", Publisher International lighting Academy.	
[T2]	Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher -York, PA : Visions Communications	
[T3]	M. A. Cayless, A. M. Marsden, "Lamps and Lighting", Publisher-Butterworth Heinemann (ISBN 978-0-415-50308-2)	
[T4]	Designing with light: Lighting Handbook., Anil Valia; Lighting System 2002	
Reference Books:		
[R1]	"BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting", Manak Bhavan, New Delhi.	
[R2]	D. C. Pritchard, "Lighting", 4th Edition, Longman Scientific and Technical, ISBN 0-582-23422-0.	
[R3]	"IES Lighting Handbook", (Reference Volume 1984), Illuminating EngineeringSociety of North America.	
[R4]	"IES Lighting Handbook", (Application Volume 1987), Illuminating EngineeringSociety of North America	

[R5]	IESNA lighting Handbook., Illuminating Engineering Society of North America 9th edition 2000
[R6]	Applied Illumination Engineering, Jack L. Lindsey FIES (Author), Scott C. DunningPHD PECEM (Author) ,ISBN-13: 978-0824748098 ISBN-10: 0824748093, 3rd Edition.
[R7]	IS 3646: Part I: 1992, Code of practice for interior illumination.
[R8]	Organic Light Emitting Diodes (OLEDs): Materials, Devices and Applications,Alastair Buckley, University of Sheffieid, UK, ISBN: 978-0-85709-425-4

Self-Learning Topics :

- Dependence of human activities on light, Good and bad effects of lighting and perfect level of illumination
- Artificial lighting as substitute to natural light, Ability to control natural light

Assignment Topics :

Assignment 1 Assignment 2 Assignment 3	• Importance of lighting in human life , different light sources and electrical control of light sources • Design considerations for illumination schemes, Indoor lighting design schemes • Outdoor lighting design schemes, Modern trends in illumination

****

Project Stage-II

Course Name : Project Stage-II 2019 Course **Course Number : 403152**		
Teaching Scheme **Tutorial : 12 Hrs. / week**		**Examination Scheme [Marks]** **Oral : 50 Marks** **Term Work : 100 Marks**
Designation of the Course : Professional-Core		
Prerequisites : All subjects		
Course Objectives :		
1.	Provide an opportunity to learn new software, interdisciplinary theory, concepts, technology, etc. not covered in earlier subjects.	
2.	Empower students to use engineering knowledge and skills learned in previous courses to deliver a product that has passed through the design, analysis, testing, and evaluation.	
3.	Encourage multidisciplinary project work through the integration of knowledge.	
4.	Allow students to develop problem-solving, analysis, synthesis, and evaluation skills.	
5.	Encourage teamwork.	
6.	Improve students' communication skills by asking them to produce both a professional report and to give an oral presentation.	
7.	Exposed to the project management skills and ethical practices in project.	
Course Outcomes : **At the end of the course, a graduate will be able to –**		
CO1	Identify tools, techniques, methods, concepts, measuring devices, and instruments required for the project to define the methodology of the project.	
CO2	Justify the selection of electrical, electronic and mechanical components for the project prototyping.	
CO3	Select the appropriate testing method for system performance evaluation.	
CO4	Interpret results obtained by simulation, and hardware implementation and decide on further action or write a conclusion.	
CO5	Write a project report and research paper on the project work.	
Course Contents :		
Guidelines to students: 1. Continue with the same group and identify opportunities for self-learning and upgrading skills. 2. Actively participate in all the activities related to the project. 3. Document the project in the form of a hard-bound report at the end and submit it to the department. 4. Attempt to make a prototype, working model, and demonstration of the project to display during the final presentation. 5. Participate in project competitions, paper presentations, etc. 6. Maintain an institutional culture of authentic collaboration, self-motivation, peer learning, and personal responsibility. 7. Maintain a notebook to keep records of all the meetings, discussions, notes, etc. This is to be done by the individual student and submitted at the end to the supervisor or guide. 8. Some parameters, mentioned in the above table, will be evaluated and assessed at a group level and some at an individual level.		

Semester 2			
Sr. No.	**Activity**	**Deadline (Semester II)**	**Parameters for Evaluation**
1	Progress Review-3 Presentation	Up to 6th Week	• Revised Final Design (10) • Tools and Techniques Used with justification (10) • Partial Implementation/ development (15) • Partial Results (15) **Total Marks (50)**
2	Progress Review-4 Presentation	Up to 12th Week	• Implementation Status of project (10) • Testing and Evaluation (10) • Intermediate Results (15) • Conclusion (10) • Future Scope (5) **Total Marks (50)**
3	Submission of Project Stage –II Report	Up to 14th Week	• Timely submission (5) • Formatting and Report Writing Style (5) • Abstract, Literature Survey, Conclusion (10) • Grammatical correctness in the report (5) • Publication/participation in project exhibition (20) **Total Marks (50) Review 3+ Review 4+ Final Project Report = 150 Rounded to 100 Marks**

Engineering Economics-II

Course Name : Audit Course – VIII - Engineering Economics-II **Course Number : 403153B**		
Teaching Scheme **Theory : 2 Hrs. / week**	**Credits** **Nil**	**Examination Scheme [Marks]** **In Sem: -** **End Sem : -**

Type of the Course :

Course Objectives :

1.	Describe basics methods of Engineering Economic Analysis
2.	Explain inflation and its impact on business decisions.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1	Apply various techniques for evaluation of engineering projects.
CO2	Assess cash flow under risk with varying parameters.

Course Contents :

Unit 1 :	**Engineering Economic Analysis**	**[10 Hrs]**

Internal Rate Of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Public Sector Economic Analysis (Benefit Cost Ratio Method).Introduction to Lifecycle Costing, Introduction to Financial and Economic Analysis.Case Study – Tata Motors

Unit 2 :	**Inflation and Risk Analysis**	**[10 Hrs]**

Concept of Inflation., Measuring Inflation, Equivalence Calculation Under Inflation, Impact of Inflation on Economic Evaluation. Sources of Project Risks, Methods of Describing Project Risks, Sensitivity Analysis, Break Even Analysis, Scenario Analysis, Probability Concept of Economic Analysis, Decision Tree and Sequential Investment Decisions

Text Books :

[T1]	Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India.
[T2]	D.M. Mithani, Principles of Economics. Himalaya Publishing House

Reference Books :

[R1]	Sasmita Mishra, "Engineering Economics & Costing ", PHI
[R2]	Sullivan and Wicks, " Engineering Economy", Pearson
[R3]	R. Paneer Seelvan, " Engineering Economics", PHI
[R4]	Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc.

****