Structure for Final Year Electrical (Electronics and Power) Engineering from Academic Year 2019- 20

Choice Based Credit System

Semester- I

Sr. No	Code	Subject	Contact Period (Hrs.)			Credits	Continuous Evaluation in terms of Marks						
							Class Test I	Class test II	Theory			Practical & Viva-voce	Total
			L	T	P				TA	ESE	TW		
1.	*	Open Elective II	3	-	-	3	15	15	10	60	-	-	100
2.	*	Open Elective III	3	-	-	3	15	15	10	60	-	-	100
3.	EE4001	Electrical Drive	3	-	-	3	15	15	10	60	-	-	100
4.	**	Professional Elective- I	4	-	-	4	15	15	10	60	-	-	100
5.	**	Professional Elective- II	4	-	-	4	15	15	10	60	-	-	100
6.	EE4002	Lab- Electrical drive		-	2	1	-	-	-	-	25	25	50
7.	EE4003	Lab- Innovation/Mini Project/ Seminar	-	-	2	1	-	-	-	-	25	-	25
8.	EE4004	Project Phase I	-	-	4	2	-	-	-	-	100	50	150
9.	#EE4005	Internship/ Industrial Training	-	-	1	1	-	-	-	-	25	-	25
		A] Total of Semester I	17	-	09	22	75	75	50	300	175	75	750

Semester- II

Sr. No	Code	Subject	Contact Period (Hrs.)			Credits	Continuous Evaluation in terms of Marks						
							Class Test I	Class test II	Theory			Practical & Viva-voce	Total
			L	T	P				TA	ESE	TW		
	*	Open Elective-IV	3	-	-	3	15	15	10	60	-	-	100
1.	**	Professional Elective-III	4	-	-	4	15	15	10	60	-	-	100
2.	**	Professional Elective-IV	4	-	-	4	15	15	10	60	-	-	100
3.	**	Professional Elective-V (Self Study)	4	-	-	4	15	15	10	60	-	-	100
4.	EE4006	Project Phase II	-	-	12	6	-	-	-	-	200	100	300
5.	EE4007	High Voltage Engineering and Electrical Equipment Specifications Lab	-	-	2	1	-	-	-	-	25	25	50
		B] Total of Semester II	15	-	14	22	60	60	40	240	225	125	750
		Total of Semesters (A+B)	32	0	23	44	135	135	90	540	400	200	1500

L-Lectures, T-Tutorials, P-Practicals, TA-Teacher Assessment, ESE-End-Semester Examination

External Examiner may be appointed from the same university

* Select any one course from the list of open elective course from Institute website

Internship/Industrial Training: The student has to undergo internship/industrial training of minimum one month after fourth or sixth semester with minimum of two weeks in one attempt. The student has to give presentation on the same in subsequent semester.

****Select any one course from list of Professional Elective Group**

Mandatory Courses (MC) (Non Credits):

As per the list received from Dean, extra-curricular activities.

 # List of Professional Electives I, II, III, IV and V

	Group A	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**	**Group G**	**Group H**
Professional Elective - I (Any one from A to H)	EE4008 Power Quality And Its Mitigation	EE4009 Digital Control System	EE4010 Design of Electrical Machine	EE4011 Illumination Engineering	EE4012 Digital Signal Processing	EE4013 HVDC Transmission Systems	EE4014 FACTS	EE4015 Energy Storage Technology
Professional Elective - II (Any one from A to H)	EE4016 Extra High Voltage AC Transmission System	EE4017 Process Control	EE4018 Electrical Machine Modeling and Analysis	EE4019 Solar Thermal and PV Technology	EE4020 Integrated Analog Circuits	EE4021 Biomedical Instrumentations	EE4022 Reliability and Condition Monitoring	EE4023 Smart Grid Technology
Professional Elective - III (Any one from A to H)	EE4024 High Voltage Engineering	EE4025 Non-linear Control Systems	EE4026 Special Machines	EE4027 Electric Traction	EE4028 Power Plant Engineering	EE4029 Electric Vehicle	EE4030 Design of Transformer	EE4031 Estimation Testing and Maintenance
Professional Elective - IV (Any one from A to H)	EE4032 Advanced Switchgear and Protection	EE40233 Advanced Instrumentations	EE4034 Advanced Power Electronics	EE4035 Grid Integration of Renewable		EE4036 Utilization of Electrical Energy	EE4037 Energy Conservation and Management	EE4038 Wind Energy System
Professional Elective - V Self Study (Any one from A and B)	EE4039 Applications of Power Electronics-A	EE4040 Applications of Power Electronics-B						

EE 4001: ELECTRIC DRIVES	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Total Credits : 3	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers Assessment : 10 Marks End-Semester Exam : 60 Marks

Pre-Requisites: Power Electronics, Electrical Machines.

Course Description: In this curriculum, students will be explored to fundamentals, control and operation of AC & DC drives. They will be also introduced to solar powered & battery powered electrical drives and traction drives. They are expected to identify the scope of electrical drives in industries.

Course Objectives:
The objective of the course is to give exposure to the students of -
1. Fundamental of electrical drives.
2. Control & operation of AC & DC drives.
3. Various industrial applications of AC and DC drives.

Course Outcomes:
The students will be able to

CO1: Describe the fundamentals of electrical drives and solve numerical on it
CO2: Discuss and analyze performance of DC motor drives
CO3: Explain and analyze controlled rectifier fed and chopper fed dc drives
CO4: Explain and analyze induction motor drives and its control
CO5: Discuss and identify industrial applications of electrical drives

UNIT-I	**Fundamentals of Electrical Drives:** Concept of electrical drives, Fundamental torque equation, Speed Torque conventions & multi-quadrant operation, Equivalent value of drive parameters, Components of load torque, Nature & classification of load torque, Calculation of time and energy-loss in transient operations, Steady state stability, Load equalization Modes of operation, Closed loop control, Selection of motor power rating
UNIT-II	**DC Motor Drives:** DC motor and their performance, Starting, Braking- Regenerative, Dynamic and Plugging, Transient analysis, Speed control, Transient analysis, Energy losses during transient operations
UNIT-III	**Control of DC Drives:** Controlled rectifier circuits, 1-phase fully and half controlled rectifier-control, 3-phase fully and half controlled rectifier control, Multi quadrant operation of fully-controlled rectifier-fed DC motor, Chopper control of separately excited dc motor, Chopper control of series motor
UNIT-IV	**Induction Motor Drives and control:** Analysis and performance of 3-phase induction motors, Starting, Braking-Regenerative, Dynamic and Plugging, Speed control, Voltage source inverter (VSI) and Current source inverter (CSI), Slip power recovery- Static Scherbius drive and Static Kramer drive, Control of 1-phase induction motor

UNIT-V	**Industrial Applications:** Solar powered drives, Battery powered vehicles, Important features of Traction drive, Traction motors, Traction drives, Semiconductor converter controlled traction drives, Other industrial applications

Text Books:

1) G. K. Dubey, "Fundamental of Electrical Drives", Second Edition. Narosa Publishing House, New Delhi, India.
2) M. H. Rashid, "Power Electronics", III Edition (Low Price), Pearson Education Pvt. Ltd. New Delhi, India.
3) B. K. Bose, "Modern Power Electronics and AC Drives", Low Price Edition, Pearson Education Pvt. Ltd. New Delhi, India.
4) R. Krishnan, "Electrical Motor Drives: Modeling, Analysis and Control", Low Price Edition, Prentice Hall of India, New Delhi, India.

Mapping of Course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	3	2	1		1	1		2	2	2		2		3	
CO2	3	2	1		1	1		2	2	2		2		3	
CO3	3	2	1		2	1		2	2	2		2		3	
CO4	3	2	1		2	1		2	2	2		2		3	
CO5	3	3	1		1	2		2	2	2		2		3	

1 – LOW 2 – MEDIUM 3 – HIGH

Teacher's Assessment:

Teacher assessment will be based on **any ONE** of the following:

1. Multiple Choice Objective Test : 10 Marks
2. Assignments/PPT presentation on allotted topics : 10 Marks
3. Quiz : 10 Marks
4. Surprise Test : 10 Marks

EE 4002: LAB ELECTRIC DRIVES	
Teaching Scheme Practical : 2 Hrs/Week Total Credits : 1	**Examination Scheme** Term Work : 25 Marks Practical Examination : 25 Marks

Course Objectives:

The objective of the course is to give exposure and hands on training to the students to

1. Operate and carry out performance analysis of DC motor drives
2. Operate and carry out performance analysis of AC motor drives

Course Outcomes:

The students will be able to

CO1: Demonstrate basic operations of AC and DC drives
CO2: Use AC & DC drives
CO3: Analyze performance of AC and DC drives
CO4: Record the operations and write technical reports
CO5: Work individually and in a team effectively

List of Experiments:

Term work shall consist of record of minimum eight experiments based on performance, software modeling and study from the following list

Sr. No.	Details
1	Three experiments based on study and/ or modeling and simulation of electrical drives using MATLAB/SIMULINK or any electrical software
2	Direction control and speed control of DC motor drives
3	Starting, stopping and accelerating & decelerating time adjustments of DC motor drives
4	Braking and protection of DC motor drives
5	Performance characteristics of DC motor drives using Jones Chopper
6	Starting, stopping and accelerating & decelerating time adjustments of AC motor drives
7	Torque-speed characteristics of AC motor
8	V/F ratio control of AC motor drive
9	Speed control of 3-phase slip ring induction motor
10	Study of industrial applications of AC motor drives
11	Study of industrial applications of DC motor drives

Term Work:

The term work shall consist of performance of above enlisted experiments and submission of technical write up. The term work will be assessed by Course Coordinator.

Practical Examination:
The practical examination will comprise of performance of any one experiment and viva voce on the complete curriculum of the course. The internal and external examiners appointed by Controller of Examination will assess the performance of the student.

Mapping of Course outcomes with program outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3									1		2		3	
CO2	3		1	2	3			2		2		2		3	
CO3	3	3	1	2	3			2		2		2		3	
CO4								2		2		2		3	
CO5								2	3	2		2		3	

1 – LOW 2 – MEDIUM 3 – HIGH

EE 4003: Lab Innovation/Mini project/Seminar	
Teaching Scheme Practical: 2 Hrs/Week Credit : 1	**Examination Scheme** Term Work : 25 Marks

A. Lab innovation/Mini Project

Lab innovation/ Mini project will be implemented as below-

1. Group size should be restricted to maximum four students.
2. Lab innovation/ Mini project will be working model.
3. Lab innovation/ Mini project will be assessed by a panel of three examiners.

The examiners may be from Electrical Department of the institute.

B. Seminar

Students will present seminar on upcoming topics selected.

Term Work:

The report on Lab innovation/mini project/seminar will be submitted on the selected topic. The minimum pages for report will be 25 which may consist of present scenario, impact on environment and society.

EE 4004: Project Phase-I	
Teaching Scheme Practical : 4Hrs/Week Credit : 2	**Examination Scheme** Term Work : 100 Marks Practical viva : 50 Marks Total : 150 Marks

Term Work

It is expected that the broad area project shall be finalized by the student in the beginning of the semester. Approximately 50% work shall be completed by the end of semester VII. Students shall give the presentation on the project and shall submit the progress report in the following format.

i. Title
ii. Abstract
iii. Introduction
iv. Project objectives
v. Literature survey
vi. Case study/ Analysis/ Design Methodology
vii. Work to be completed
viii. Expected results and conclusion
ix. References

EE 4005: INTERNSHIP /INDUSTRIAL TRAINING SEMINAR	
Teaching Scheme	**Examination Scheme**
Practical : 1Hr/Week	Term Work : 25 Marks
Total Credits : 1	Total : 25 Marks

1. Student will undergo Internship /Industrial training for four to six weeks with minimum of two weeks in one attempt.
2. Students will present seminar on Internship /Industrial training.
3. Students will submit report on Internship /Industrial training.

EE 4006: Project Phase-II	
Teaching Scheme Practical : 12 Hrs/Week Total Credits : 6	**Examination Scheme** Term Work : 200Marks Practical work : 100 Marks Total : 300 Marks

Term Work:

1. Students will demonstrate the project and present the seminar on the project.
2. Project report contains minimum 50 pages and it will have one section on impact of proposed idea/work on environment and society.

EE 4007: High Voltage Engineering and Electrical Equipment Specification Lab			
Teaching Scheme		**Examination Scheme**	
Practical	: 2Hrs/Week	Term Work	: 25 Marks
Total Credits	: 1	Practical work	: 25 Marks
		Total	: 50 Marks

Course Coordinator will discuss the basic concepts related to the High Voltage Engineering experiments to be conducted.

Term Work:
The term work shall consist of record of minimum five experiments from the list given below.
1. Measurement of dielectric strength of transformer oil
2. Measurement of High A.C. Voltage using sphere gap
3. Measurement of breakdown strength of solid insulating material
4. Impulse voltage test on insulator
5. Power frequency test on insulator
6. Tan δ measurement of insulator
7. Study of Impulse Generator
8. Calibration of E. S. V.

and
record of-detailed specifications of any three and study of rating, manufacturing process of any one of the following electrical equipment list- on the basis of survey conducted by the group of students

List of the equipment:
1. Various types of circuit breakers
2. Various lights/luminaries
3. Distribution transformers
4. Instrument transformers
5. Solar water heater
6. All types of industrial fans
7. D-G sets
8. All pumps

Syllabus for Professional Electives I, II, III, IV & V

EE4008 : Power Quality and its Mitigation (Professional Elective I)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-Requisites: Electrical Machines, Electrical Measurements, Power Systems
Course Description: This course gives an introduction on power quality causes and effects, requirement of power quality improvements and mitigation aspects of power quality problem.

Course Objectives:
The objectives of the course are to
1. Understand power quality problem and classify power quality events
2. Understand different methods of monitoring power quality and standards for power quality
3. Outline concept of Passive shunt and series compensators
4. Understand Active Shunt and Series Compensators
5. Understand Unified Power Quality Compensators

Course outcomes:
After completing the course, students will able to

CO1.	Describe Power quality problems and classify power quality events.
CO2	Demonstrate power quality measurement methods
CO3	Explain principle of operation and control of Passive shunt and series compensators.
CO4	Design of Active Shunt And Series Compensators
CO5	Analyze Unified Power Quality Compensators

UNIT-I	**Power Quality an Introduction:** Introduction, Classification of Power quality problems, Causes of power quality problems, Loads that cause power quality problem, classification of nonlinear load, Effects of power quality problems on users, Classification of mitigation techniques for power quality problems
UNIT-II	**Power Quality Standards and Monitoring:** Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, classification of passive power filter, principle of operation of passive power filter
UNIT-III	**Passive Shunt and Series Compensation:** Classification of Passive shunt and series compensators, Principle of operation of Passive shunt and series compensators, Analysis and design of Passive shunt compensators
UNIT-IV	**Active Shunt And Series Compensation:** Classification of DSTATCOMs, principle of operation and control of DSTATCOM, analysis and designed of DSTTCOM, Classification of active series compensators, principle of operation and control of active series compesators, Analysis and designed of active series compensators
UNIT-V	**Unified Power Quality Compensators:** Classification of Unified power quality compensators, principle of operation and control of Unified power quality compensators, analysis and designed of Unified power quality compensators

Text and Reference Books:

1. Bhim Singh, AmbrishChandra(2015) "Power Quality Problem and Mitigation Techniques" , Wiley Publications (ISBN: 9781118922057)
2. C.Sankaran (2002)" Power quality"CRC Press Publication.
3. Math, H.J. Bollen, "Understanding power quality problem", Standard Publication.
4. Roger C. Dugan, "Electrical power system quality"2nd edition, macgraw-Hill Publication.
5.MohammedA.S.Masoum,EwaldF.Fuchs" Power Quality in power systems and electric machines",2nd Edition, Kindely edition,(ISBN: 978-0123695369)

Mapping of Course outcome with Program Outcomes

Corse outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	1	2	1	1	1	1	1	1	1	1	2	2	
CO2	3	2	1	2	1	1	1		1	1	1	1	2	2	
CO3	3	2	1	1	1	1	1	1	1	1	1	1	2	2	
CO4	3	2	1	2	1	1	1		1	1	1	1	2	2	
CO5	3	2	1	2	1	1	1		1	1	1	1	2	2	

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment:

Teacher's Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. Multiple choice questions test
4. Quiz

EE4009: Digital Control System (Professional Elective I)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: EE3005 Control systems

Course description: The purpose of this course is to teach students the fundamental of Digital control systems

Course Objectives:

The objectives of the course are to

1. Explain signal conversion, sampling, reconstruction of signals
2. Illustrate transform analysis of sample data system
3. Explain the design of digital control system
4. Describe the tools of analysis of digital control system
5. Illustrate the modern control techniues

Unit wise Course Outcomes Expected
After completion the course, students will able to:

CO1	To analyze, design and model the signal conversion devices
CO2	To describe the mathematical tools to analyze the discrete time control system
CO3	To design the control system in digital domain using classical design techniques
CO4	To describe the tools of state space analysis for digital control system
CO5	To design control system using state space techniques

Detailed Syllabus:

UNIT-I	Sampling and reconstruction : Sampled data control system, digital to analog conversion, analog to digital conversion, sample and hold operation, frequency domain consideration in sampling
UNIT-II	Transform analysis of sampled data system : Linear difference equation, the pulse response, the Z-transform, the pulse transform, block diagram analysis of sample data systems, Z-domain equivalents to S-domain compensator, stability analysis, systems with dead time.
UNIT-III	Transform design of digital controls: Design specification, design on the w and w'-plane, design on the z-plane, digital PID controller, discrete time state equations similarity transformation.
UNIT-IV	State space analysis of sample data systems: Discrete time state equations, similarity transformations, The cayley-Hamilton theorem, Realization of pulse transfer functions, state equations for sample data systems, concept of controllability and observability.

Unit -V	Design of Digital controls: Formulation of the optimal control problem, Optimal state regulators, Eigen value assignment by state feedback, state observer

Text and Reference Books:

1. Digital control engineering, M. Gopal, New Age International publication, second edition
2. Control system Engineering, I. J. Nagrath and M. Gopal, New Age International publishers, third edition
3. Discrete-time control systems, Katsuhiko Ogata, Second Edition, PHI publication

Mapping of Course outcome with Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Po 13	PO 14	PO 15
CO1	1	1	1		2										3
CO2	1	3	1		2										3
CO3	1	2	2	2	2										3
CO4	1	3	2	2	2										3
CO5	1	2	2	2	2										3

1- LOW 2- MEDIUM 3- HIGH

Teaching strategies :

The teaching strategy is planned through the lectures, tutorials, and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment: Teachers Assessment based on one of the / or combination of both of the following.

1. Assignments
2. MCQ

EE4010: Design of Electrical Machine (Professional Elective I)	
Teaching Scheme	**Examination Scheme**
Lectures : 04 Hrs/Week	Class Test I : 15 Marks
Tutorial : 00	Class Test II : 15 Marks
Total Credits : 04	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Pre-requisites: EE2008 :Electrical Machines-I
EE3002 :Electrical Machines-II

Course Description:
EE4023 Design of Electrical machine is selective subject to all students of the Electrical Engineering Department. Course is aimed to introduce fundamental concepts regarding machine design with electrical aspects of all types of machines to undergraduate students. The goal of this course is to understand and apply fundamentals knowledge of design to design all machines including transformer.

Course Objectives:
The objectives of the course are to learn

- To study Selection proper commercial materials, their properties and selection criterions, IS standards used in electrical machine design.
- To study design of commercial induction motor and transformer

Course Outcomes:
After completing the course, students will able to

CO1	Explain basic considerations required for electrical machine design
CO2	Explain design stator and rotor of induction machines as per the specifications
CO3	Identify and solve problems on performance parameters the Induction motor
CO4	Demonstrate the design core, yoke, windings and cooling systems of transformers
CO5	Solve design problems related to performance of transformer

Detailed Syllabus:

UNIT-I	Major considerations in Electrical Machine Design – Electrical Engineering Materials – Space factor – Choice of Specific Electrical and Magnetic loadings – Thermal considerations – Heat flow – Temperature rise and Insulating Materials – Rating of machines – Standard specifications.
UNIT-II	DESIGN OF INDUCTION MOTORS-I: Constructional features, types of ac windings, Output equation of Induction motor , Main dimensions, specific electrical and magnetic loadings, ranges of specific loadings, turns per phase, number of stator slots. Length of air gap- Rules for selecting rotor slots of squirrel cage machines, Design of rotor bars & slots , Design of end rings, Harmonic field effect on the performance of three phase induction motor, Specifications of Induction motor
UNIT-III	DESIGN OF INDUCTION MOTORS-II: Magnetic leakage calculations – Leakage flux and leakage reactance: Slot leakage, tooth top leakage, zig-zag leakage, overhang leakage, leakage reactance calculation for three phase machines.MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on

	calculations of magnetizing current, calculations of no-load current. Calculations of losses and efficiency
UNIT-IV	DESIGN OF TRANSFORMERS - I Types and constructional features of core and windings used in transformer. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of transformer. Output Equations, Design of Main Dimensions – KVA output for single and three phase transformers – Window space factor – Design of core and winding – Overall dimensions, Design of Tank, Methods of cooling of Transformers
UNIT-V	DESIGN OF TRANSFORMERS - II Estimation of resistance and leakage reactance of transformer, No load current, losses, efficiency and regulation of transformers. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Temperature rise in Transformers

Text Books:

1. M.G. Say, Theory and Performance and Design of A.C. Machines, 3rd Edition, ELBS London
2. Sawhney A.K., 'A Course in Electrical Machine Design', DhanpatRai& Sons, New Delhi, 1984.

Reference Books:

1..Indrajit Dasgupta,Design of Transformers, TMH
2. M.V.Deshpande "Design and Testing of Electrical Machine Design" Wheeler Publications, 2010.
3.A.Shanmuga Sundaram, G. Gangadharan, R.Palani 'Electrical Machine Design Data Book', New Age International Pvt. Ltd., Reprint, 2007.
4.R.K.Agarwal" Principles of Electrical Machine Design" Esskay Publications, Delhi, 2002.
5. K. G. Upadhyay, Design of Electrical Machines, New age publication.
6.Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.
7. Vishnu Murti, "Computer Aided Design for Electrical Machines", B.S. Publications.

Mapping of Course Outcome with Program Outcomes:

Course outcome	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PO 11	PO 12	PSO 13	PSO 14	PSO 15
CO1	3	2													
CO2	3	2	3		1	1						1		3	
CO3	3	2	3		1	1						1		3	
CO4	3	2	3		1	1						1		3	
CO5	3	3	3		1	1						1		3	

1- LOW 2- MEDIUM 3-HIGH

Teaching Strategies:
The teaching strategy is planed through the lectures and team based home works. Execises are assigned weekly to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment:
Teacher's Assessment is based on one of the /or combination of the few of the following.

1. Home Assignments
2. Power point presentation on new concepts in design in any type of machine
3. Develop working models using software
4. Surprise written Test with multiple choice questions
5. Quiz

EE4011: Illumination Engineering (Professional Elective I)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Course Description:

EE4029Illumination Engineering is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. Explain different light bulb technologies, and design of light reflector.
2. Eevaluate the impact of different light technologies on society.
3. Conduct cost benefit analysis and evaluate different solutions using set criteria.
4. Compare the relative proportions of light and heat released by different types of bulbs.
5. Design lighting scheme for indoor and outdoor space

Course Outcomes:

After completing the course, students will be able to:

CO1	State and define the need for good illumination
CO2	State and describe the protection, wiring and control circuits for luminaries.
CO3	Explain the construction, operation of different light sources
CO4	Design and examine indoor lighting systems.
CO5	Design and examine outdoor lighting systems.

Detailed Syllabus:

Unit 1	**Lighting in Human Life:** Radiation, color, eye & vision; different entities of illuminating systems; time luminance, Good and bad effects of lighting & perfect level of illumination, physics of generation of light, Properties of light, Quantification & Measurement of Light, Laws of illumination; illumination from point, line and surface sources. Photometry and spectrophotometer, photocells, Environment and glare.
Unit 2	**Luminaries wiring, switching and control circuits:** Types of Luminaries, factors to be considered for designing luminaries, optical control schemes, design of reflecting and refracting type of luminaries, physical protection of lighting fixtures, types of lighting fixtures, luminaries standard (IEC-598-Part I). Utility services for large building/office complex and layout of different meters and protection units. Different type of loads and their individual protection. Selection of cable/wire sizes; potential sources of fire hazards and precautions. Emergency supply-stand by and UPS.
Unit 3	**Light Sources:** Daylight, incandescent, electric discharge, fluorescent, arc lamps and

	lasers. Lamp materials, Construction, working, design considerations and characteristics of discharge lamps, low and high mercury and Sodium vapour lamp, fluorescent Lamp, compact Fluorescent Lamp (CFL), Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps.
Unit 4	**Design of Indoor lighting**: Factors to be considered for design of indoor illumination scheme, Illumination design for residential, hospitals, industrial lighting, office, departmental stores, theatre, Indoor stadium, swimming pool, and special purpose lighting schemes.
Unit 5	**Design of Outdoor lighting:** Factors to be considered for design of outdoor illumination scheme, flood lighting, aviation and transport lighting, lighting for displays and signaling – neon signs, LED – LCD displays beacons and lighting for surveillance. Street lighting, classifications according to BIS, pole arrangement, terminology, lamp and luminaries selection, point by point method, problems on point by point method.

Text and Reference Books

1. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy
2. Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher - York, PA : Visions Communications
3. M. A. Cayless, A. M. Marsden, "Lamps and Lighting", Publisher-Butterworth-Heinemann(ISBN 978-0-415-50308-2)
4. Designing with light: Lighting Handbook., Anil Valia; Lighting System 2002
5. "BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting", ManakBhavan, New Delhi
6.. D. C. Pritchard, "Lighting", 4th Edition, Longman Scientific and Technical, ISBN 0-582-23422

Mapping of Course Outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	1	2				1	1	1				1	3		
CO2	1	2	1			1	1	1				1	3		
CO3	1	2	1			1		1				1	3		
CO4	1	2						1				1	3		
CO5	1	2						1				1	3		

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on assignments and quiz. However, the course co-ordinator has to announce assessment components at the beginning of the course.

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form.

EE4012 : Digital Signal Processing (Professional Elective I)	
Teaching Scheme	**Examination Scheme**
Lectures : 4 Hrs/Week	Test I : 15 Marks
Tutorial : NIL	Test II : 15 Marks
Total Credits : 4	Teachers Assessment : 10 Marks
	End Semester Exam : 60 Marks

Course Description: This is the course in Electrical Engineering which introduces the basic concepts and techniques for processing signals on a computer and be familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.

Prerequisites:
EE2002=Network Analysis
EE3002=Electrical Machines-II
EE3005=Control Systems I

Course Objectives:
The objectives of the course are to give exposure of

1. Introduce the basic concepts and techniques for processing signals on a computer.
2. Be familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.
3. Emphasizes intuitive understanding and practical implementations of the theoretical concepts.

Course Outcomes:
After completing the course, students will able to:

CO1	Characterize and analyze various discrete-time signals analytically and visualize them in the time domain.
CO2	Transform and analyze discrete-time signals implications of the properties of systems and signals.
CO3	Understand parameters of digital filter design for continuous time signals
CO4	Specify and design digital filters for continuous time signals
CO5	Apply filter design for real time signals

Detailed Syllabus:

Unit 1	**Signals and Signal Processing:** Characterization and Classification of Signals, Typical Signal Processing Operations, Examples of Typical Signals, Typical Signal Processing Applications, Why Digital Signal Processing? **Discrete-Time Signals and Systems in the Time-Domain:** Discrete-Time Signals, Typical Sequences and Sequence Representation, the Sampling Process, Discrete-Time Systems, Time-Domain Characterization of LTI Discrete-Time Systems, Finite-Dimensional LTI Discrete-Time Systems, Correlation of Signals, Random Signals
Unit 2	**Transform-Domain Representations of Discrete-Time Signals** The Discrete-Time Fourier Transform, Discrete Fourier Transform, Relation Between the DTFT and the DFT, and Their Inverses, Discrete Fourier Transform Properties, Computation of the DFT of Real, Sequences, Linear Convolution Using the DFT, The z-Transform, Region of Convergence of a Rational z-Transform, The Inverse z-Transform, z-Transform Properties, Transform-Domain Representations of Random Signals

	LTI Discrete-Time Systems in the Transform-Domain Finite-Dimensional LTI Discrete-Time Systems, The Frequency Response, The Transfer Function, Types of Transfer Functions, Simple Digital Filters, All-pass Transfer Function, Minimum-Phase and Maximum-Phase Transfer Functions, Complementary Transfer Functions, Inverse Systems, System Identification, Digital Two-Pairs, Algebraic Stability Test, Discrete-Time Processing of Random Signals, Matched Filter
Unit 3	**Digital Processing of Continuous-Time Signals** Introduction, Sampling of Continuous-Time Signals, Sampling of Bandpass Signals, Analog Lowpass Filter Design, Design of Analog Highpass, Bandpass, and Bandstop Filters, Anti-Aliasing Filter, Design of Sample-and-Hold Circuit, Analog-to-Digital Converter, Digital-to-Analog Converter, Reconstruction Filter Design, Effect of Sample-and-Hold Operation.
Unit 4	**Digital Filter Structures** Block Diagram Representation, Equivalent Structures, Basic FIR Digital Filter Structures, Basic IIR Filter Structures, Realization of Basic Structures using MATLAB, All pass Filters, Tunable IIR Digital Filters, IIR Tapped Cascaded Lattice Structures, FIR Cascaded Lattice Structures, Parallel All pass Realization of IIR Transfer Functions, Digital Sine-Cosine Generator
Unit 5	**Digital Filter Design** Preliminary Considerations, Bilinear Transform Method of IIR Filter Design, Design of Low pass IIR Digital Filters, Design of Highpass, Bandpass, and BandstopIIR Digital Filters, Spectral Transformations of IIR Filters, FIR Filter Design Based on Windowed Fourier Series, Computer-Aided Design of Digital Filters, Design of FIR Filters with Least-Mean-Square Error, Digital Filter Design Using MATLAB **Applications of Digital Signal Processing** Spectral Analysis of Sinusoidal Signals, Spectral Analysis of Nonstationary Signals, Spectral Analysis of Random Signals

Text Books:

1. R. Babu. , "Digital Signal Processing", Laxmi Publication Ltd.
2. A. Ambardar, "Digital Signal Processing: A Modern Introduction", Penram International Publishing (India) Pvt. Ltd.

Reference Books:

1. Proakis, "Digital Signal Processing", Pearson Education Limited
2. Oppenheim and Schafer, "Discrete-Time Signal Processing", Prentice-Hall, 1989.
3. Rabiner, R. Lawrence, "Theory and Application of Digital Signal Processing", Gold, Bernard, Prentice-Hall

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	2	1	3		2	2			1	1	1	2	1
CO2	3	3	2	1	3		2	2			1	1	1	2	1
CO3	3	3	2	1	3		2	2	1		1	1	1	2	1
CO4	3	2	2	1	3	1	1	2	1			1	1	2	1
CO5	3	1	2	1	3	1	1	2	1			1	1	2	1

1 – Low 2 – Medium 3 High

Teacher's Assessment: Teachers Assessment of 10 marks is based on one of the / or combination of few of following

1. Assignments based on Numerical from exercise (unsolved problems from Text books).
2. Objective type test.
3. Solving networks problems by MATLAB. solution

EE4013: HVDC Transmission Systems (Professional Elective I)	
Teaching Scheme	**Examination Scheme**
Lectures : 04 Hrs/Week	Class Test I : 15Marks
Tutorial : 00	Class Test II : 15Marks
Total Credits : 04	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Course Description: This course aims to give introduction of the basic concepts of transfer of DC power and control of DC power and its control over DC transmission system. It covers operations, protections and faults analysis of High Voltage DC transmission systems.

Pre-Requisites: Power System Analysis, Power Electronics

Course Objectives: The objectives of the course is to give exposure to the students of
1. Principle of HVDC transmission system.
2. Concept of various control in HVDC systems.
3. Concept of harmonics and design of filter used in HVDC systems.
4. Analysis of protection used in HVDC system.

Course Outcomes:
After completing the course, students will able to:

CO1	Describe Principle of HVDC transmission system
CO2	Discuss the various methods for HVDC converter control.
CO3	Explain generation of harmonics and design of various filter.
CO4	Analyze the various fault in HVDC system.
CO5	Discuss protection schemes and issue related with it.

Detailed Syllabus:

Unit 1	Principles of HVDC Transmission: Terminal Equipments and Their Controls, Reactive Power Control. Analysis of HVDC Converters, Choice of Converter Configuration, Analysis of Graetz Circuit, Converters Bridge Characteristics, Twelve Pulse Converters, Detailed Analysis of Converter
Unit 2	HVDC System Control: DC Link Control, Converter Control Characteristics, Control of Firing Angle, Current control, Extinction Angle and Power control.
Unit 3	Harmonics and Filters: Generation of Harmonics, Design of AC and DC Filters, Carrier Frequency and Rl Noise. Multi-Terminal DC Systems, Potential Applications, Types, Control and Protection
Unit 4	Analysis of AC/DC Systems: Converter Model and Control, Modeling of AC and DC Networks, Modeling of DC Links, Solution of DC Load Flow, Per Unit System for DC Quantities, Solution of AC - DC Power Flow
Unit 5	Protection: Converter Faults, Protection Against Over Currents, Over Voltages, HVDC Circuit Breakers, Protection by DC Reactors, Insulation Coordination. Earth Return: Use of Earth and Sea Return, Advantages and Problems.

Text Books:

1. K. R. Padiyar, HVDC power transmission systems - Technology and System Interactions, New Age International Ltd.
2. E. W. Kimbark, Direct Current Transmission - Vol. I & II, John Wiley & Sons.
3. C.Adamson and N.G. Hingorani, High Voltage Direct Current Power Transmission, Garraway publications, 1960.
4.Arillaga, High Voltage Direct Current Transmission Engineering, Peter Peregrinus Ltd.UK.

Reference Books:

1. S. S. Rao, EHV - AC &HVDC transmission Engg, & Practice, Khanna Publishers
2. E. Uhlman, Power Transmission by Direct Current, Springer-Verlag.
3. B. J. Cory, HVDC Power Converters and Systems, Mc Donald publishers.

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2											2		2
CO2	3	2											2		2
CO3	3	2		1									2		2
CO4	3	2		1									2		2
CO5	3	1											2		2

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on one of the following ,

1. Assignments : 10 Marks
2. MCQ test. : 10 Marks
3. Presentation on recent topics related to HVDC :10 Marks

EE4014: Flexible A.C. Transmission System (Professional Elective I)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End-Semester Exam : 60 Marks

Prerequisites: Generation, transmission and distribution of electric Power
Power System Analysis
Power Electronics
Control Systems I

Course Objectives: The objectives of the course are to
1. Explain various types of FACT controller
2. Discuss series compensation to power system
3. Discuss shunt compensation to power system
4. Illustrate appropriate power devices and converter topologies for implementation of FACTS controller
5. Explain combined controllers such as UPFC, IPFC

Course Outcomes:
After completing the course, students will able to:

CO1	Compare various types of facts controller
CO2	Apply shunt compensation
CO 3	Apply series compensation
CO 4	Apply combined compensation
CO 5	Apply static voltage and phase angle regulator

Detailed Syllabus:

Unit 1	FACTS Concepts: Flow of Powers in AC System, Dynamic Stability Consideration of Transmission Interconnection, Relative Importance of Controllable Parameters, FACTS Controllers
Unit 2	Static Shunt Compensator: Methods of Controllable VAR Generation, Static VAR Compensators, Static VAR Systems
Unit 3	Static Series Compensator: Variable Impedance Type Series Compensators, Switching Converter Type Series Compensators, External Control for Series Reactive Compensators
Unit 4	Combined Compensators: Unified Power Flow Controller, Interline Power Flow Controller, Generalized and Multifunctional FACTS Controllers
Unit 5	Static Voltage and Phase Angle Regulators: TCVR and TCPAR, Objectives of voltage and phase angle regulators, Approaches to Thyristor-controlled voltage and phase angle regulators (TCVRs and TCPARs), switching converter based voltage and phase angle regulators, Hybrid phase angle regulators. Special Purpose FACTs controllers: NGH-SSR damping scheme and thyristor-controlled

Text/ Reference Books:

1. N.G. Hingorani, "Understanding FACTS", IEEE Press, 1999
2. Yang hue song, "Flexible AC Transmission Systems (FACTS)", IEEE Press, 1999).

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	2	1		1						1	3	2	
CO2	3	1	2	1		1						1	3	2	
CO3	3	1	2	1		1						1	3	2	
CO4	3	1	2	1		1						1	3	2	
CO5	3	1	2	1		1						1	3	2	

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on any one of the following,

1. Assignments : 10 Marks
2. MCQ test. : 10 Marks

EE4015 : Energy Storage Technology (Professional Elective I)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End-Semester Exam : 60 Marks

Pre-Requisites: Renewable Energy Technology, Power Systems

Course Description: Coverage of energy storage techniques involving electrochemical, mechanical and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design tradeoffs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage.

Course Objectives: The objectives of the course are to
1. Understand energy storage needs
2. Understand different methods of energy storage
3. Define advantages and disadvantages of storage integration
4. Understand superconducting magnetic energy storage systems
5. Understand mechanical energy storage systems

Course Outcomes: After completing the course, students will able to

CO1.	Describe the energy storage need of the smart grid, both present and future
CO2	Compare and contrast methods of energy storage management in terms of cost, size, weight, reliability, efficiency and lifetimes
CO3	Define the advantages and disadvantages of storage integration in various energy distribution systems
CO4	Explain superconducting magnetic energy storage systems
CO5	Explain mechanical energy storage systems

Detailed Syllabus:

UNIT-I	**Necessity of Energy Storage:** Introduction to the traditional bulk power system, its layout and control, System impacts and effects of distributed generation on the operation and control of the bulk power system, Vehicle to grid integration
UNIT-II	**Electrochemical Energy Storage:** Introduction to battery storage including lead acid, lithium ion, flow, and emerging battery technologies. Comprehensive analysis of design considerations and application specific needs. Impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions.
UNIT-III	**Ultra-Capacitors:** Introduction to ultra-capacitors including operation, applications, and emerging technologies. Topics include the usage in mobile applications and close proximity to renewable energy sources. Discussion of primary target market usage in today's energy and power sectors.
UNIT-IV	**Superconducting Magnetic Energy Storage:** Introduction to Super Conducting Magnetic Energy Storage (SMES) operation, theory of usage and emergent research. Focus will primarily be on large utility scale energy storage facilities.

UNIT-V	**Mechanical Energy Storage:** Flywheel, Pumped hydro storage, compressed gas storage technologies, models for compressed gas capacity, efficiency and availability

Text and Reference Books:

1. Ter-Gazarian, A.G. (2011) *Energy Storage for Power Systems, 2nd Edition*, IET Publications (ISBN: 978-1849192194)
2. Huggins, R.A. (2010) *Energy Storage*, Springer, (ISBN: ISBN 978-1441910240)
3. R. P. Deshpande, "Ultracapacitors", McGraw Hill Education Publication.
4. Robert A. Huggins, "Energy Storage", Springer Publication.
5. Fransisco Diaz," Energy storage in power systems", published by Wiley.

Mapping of Course outcome with program outcomes:

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1	1	1	1	1	1	1	1		1	1	1	1
CO2	3	2	2	1	1	1	1	1	1	1		1	1	1	1
CO3	3	2	1	1		1	1	1	1	1		1	1	1	1
CO4	3	2	1	1		1		1	1	1		1	1		
CO5	3	2	1	1		1	1	1	1	1		1	1	1	1

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teacher's Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. multiple choice questions test
4. Quiz

EE4016: EHV AC TRANSMISSION SYSTEM (Professional Elective II)	
Teaching Scheme	**Examination Scheme**
Lectures : 04 Hrs/Week	Class Test I : 15 Marks
Tutorial : 00	Class Test II : 15 Marks
Total Credits : 04	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Prerequisites: EE2010 Power System-I

Course description: This course introduces the concepts of EHV AC Transmission System& covers the various aspects of EHV AC Transmission System.

Course Objectives: The objectives of the course are to

1. Understand the basic aspects of A.C. power transmission
2. Learn Reflection and Refraction of Traveling Waves
3. Learn various causes for over voltages**.**
4. Understand reactive power flow & voltage stability in Power Systems.
5. Learn Power Transfer at Voltage Stability Limit of EHV Lines

Course Outcomes :

After completing the course, students will able to:

CO1	Describe basic aspects of A.C. Power Transmission & evaluate surface voltage gradient on conductors
CO2	Explain fundamentals of Traveling Waves and Standing Waves
CO3	Elaborate the causes of over voltages in EHV systems
CO4	Discuss reactive power flow & stability conditions
CO5	Explain the conditions for power transfer at voltage stability limit of EHV Lines

Detailed Syllabus:

UNIT-1	Basic Aspects of A.C. Power Transmission: line trends and preliminary aspects of A.C. Power Transmission, Power-Handling Capacity and Line Loss, standard transmission voltages, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference.
UNIT-2	Traveling Waves and Standing Waves: Line Energization with Trapped - Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection Lightning & Lightning Protection, Insulation Coordination Based on Lightning
UNIT-3	Over Voltages in EHV Systems: Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Control of Power Frequency Voltages and switching Over Voltages, Power Circle Diagram.
UNIT-4	Reactive Power Flow and Voltage Stability in Power Systems: Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post- Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability

UNIT-5	Power Transfer at Voltage Stability Limit of EHV Lines: Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit

Text and Reference Books:

4. A. Chakrabarti, D. P. Kothari, A.K. Mukhopdadhyay ,"Performance, operation & control of EHV power transmission system " , wheeler publications
5. Rakosh Das Begamudre, "Extra high-voltage A.C. transmission Engineering" New Age International Pvt. Ltd.
6. S.Rao, "EHVAC & HVDC Transmission Engineering & Practice" , Khanna Publications

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Po 13	PO 14	PO 15
CO1	3	2				2	2	2	1	2		2	3	1	
CO2	3	2				2	2	2	1	2		2	3	1	
CO3	3	1				2	2	2	1	2		2	3	1	
CO4	3	1				2	2	2	1	2		2	3	1	
CO5	3	2				2	2	2	1	2		2	3	1	

1 – Low 2 – Medium 3 – High

Teacher's Assessment: Teachers Assessment of 10 marks is based on **attendance** of the student and one of the / or combination of few of following.

1.Assignments
2. MCQ
3. Quiz
4. Presentation on latest topics/Real life problems related with the course

EE 4017: : Process Control (Professional Elective II)	
Teaching Scheme	**Examination Scheme**
Lectures : 4 Hrs/Week	Class Test I : 15 Marks
Tutorial : ---	Class Test II : 15 Marks
Total Credits : 4	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Pre-requisites: NIL

Course Description: The purpose of this course is to teach students the fundamentals of Process Control.

Course Objectives: The objectives of the course are to

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between nano/micro structure, characterization, properties and processing and design of materials.
3. Have the experimental and computational skills for a professional career or graduate study in materials.
4. Possess knowledge of the significance of research, the value of continued learning and environmental/social issues surrounding materials.

Unit wise Course Outcomes expected:

Students will be able to

CO1. Analyze and determine mathematically model the processes
CO2. Evaluate the closed loop response of the controllers
CO3.Describe P-I diagram for control valves
CO4. Explain multiple loop control system
CO5. Develop ladder diagram for various systems

Detailed syllabus:

UNIT-I	**Introduction to Process Control:** Introduction, Evaluation of Process Control Concept, Definition and Types of Processes, Benefits, Difficulties and Requirements of Process Control Implementation, Classification Of Process Variable, Open Loop Versus Close Loop Control, Servo Vs Regulator Operation of Closed Loop System, Feedback and Feed Forward Control Configuration, Steps In Synthesis of Control System. **Process Dynamics And Mathematical Modeling:** Introduction, Aspects of Process Dynamics, Types Of Dynamic Processes, Common Systems, Mathematical Modeling, Types And Uses of Mathematical Modeling, Examples of Mathematical Modeling.
UNIT-II	**Theory Of Controllers:** Introduction, Classification of Controllers, Controller Terms, Discontinuous Controllers, Continues Controllers. **Closed Loop Response:** Introduction, Functions of Closed Loop, Proportional Controllers In Closed Loop, Integral Controller In Closed Loop, Proportional Controller In Closed Loop, Proportional Derivative Controller In Closed Loop, Comparison of Various Controller Configuration
UNIT-III	**Control Valves:** Introduction, Common Abbreviations In The Valve Industry, Definitions Of Terms Associated With Valves, Control Valve Characteristics, Valve Characteristics, Valve Classification And Types, Selection Criteria For

	Control Valves. **P&I Diagram :** Introduction, Definitions of Terms Used In P & I Diagram, instrument Identification, Examples of P & I Diagrams
UNIT-IV	**Control Systems With Multiple Loops:** **Cascade, Feed forward And Ratio Control:** Introduction, Cascade Control, Feed forward Control, Feed forward- Feedback Control Configuration, Ratio Controller, Components And Working of DDC, Benefits of DDC
UNIT-V	**PLC, DCS And SCADA Systems:** Introduction, Basic Parts Of A PLC, Operations Of A PLC, Basics Symbols Used In PLC Realization, Difference Between PLC And Hardwired Systems, Difference Between PLC And Computer, Relay Logic To Ladder Logic, Ladder Commands, Examples Of PLC Ladder Diagram Realization, PLC Timers, PLC Counters And Examples, Classifications OfPlcs, History Of DCS, DCS Concepts, DCS Hardware And Software, DCS Structure, Advantages And Disadvantages Of DCS, Representative DCS, SCADA, SCADA Hardware & Software

Text Books:

1. K Krishnamurthy, Process Control, Tech Max
2. G. Stephanopoulos, Chemical Process Control, PHI.
3. Process Control: Principles and Applications, Oxford University Press

Mapping of Course outcome with program outcomes:

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	1	1	2		1	1			1	1			3
CO2	3	3	1	1	2		1	1			1	1			3
CO3	3	3	1	1	2		1	1	1		1	1			3
CO4	3	2	1	1	2	1	1	1	1		1	1			3
CO5	3	1	1	1	2	1	1	1	1		1	1			3

1- LOW, 2- MEDIUM, 3- HIGH

Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment:

Teacher's Assessment based on one of the /or combination of the few of the following.

1) Multiple choice question
2) PPT presentation

EE4018: Electrical Machine Modeling and Analysis (Professional Elective II)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites:EE 2008: Electrical Machines-I
EE 3002: Electrical Machines-II

Course Description:

EE4024Electrical Machines modeling and Analysis is a one-semester course as elective to fourth year Electrical Engineering students. It is the fundamental course related to advance protection Engineering.

Course Objective:

The objectives of the course are to

To master the various fundamentals, machine design, machine modeling of various types of electrical machines. This will help you to gain knowledge and to do research in the area of electrical machine modeling.

The main objective of the course is to:

1. Know the concepts of generalized theory of electrical machines.
2. Model and analysis the electrical machines with voltage, and torque equations.
3. Know the steady state and transient behavior of the electrical machines.
4. Understand the dynamic behavior of the DC/AC, special machines.
5. Learn the issues affecting the behavior of different types machines such as sudden application of loads, short circuit etc.

Course Outcomes:

After completing the course, students will be able to:

CO1	The basic concepts of AC/ DC machine modeling.
CO2	The dynamic modeling and phase transformation
CO3	Analyze various methodologies in DCmachine modeling.
CO4	Understand the modeling of induction, synchronous machine modeling
CO5	The performance and dynamic modeling of BLDC,PMSM machines

Detailed Syllabus:

Unit 1	Basic concepts of Modeling: Basic Principles of Electrical Machine Analysis, Need of modeling, Introduction to modeling of electrical machines
Unit 2	Concept of transformation: Commonly Used Reference Frames, change of variables &m/c variables and transform variables for arbitrary reference frame. Stationary Circuit VariablesTransformed to the Arbitrary Reference Frame, Transformation Between Reference Frames, and Transformation of a Balanced Set, Balanced Steady State Phasor Relationships, And Balanced Steady State Voltage Equations
Unit 3	Modeling of Direct-Current Machine,: Voltage and Torque Equations in Machine Variables, Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis, Application to D.C. machine for steady state and transient analysis,
Unit 4	Three phase Induction Machines:

	Modelling of 3 phase Induction Motor, Voltage, torque equations, Equivalent circuit, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals.
Unit 5	Modeling Permanent Magnet Synchronous Machine: Introduction, Types of Permanent Magnet Synchronous Machines, PMAC & PMDC(BLDC) ,Voltage and torque equations in machine variables, voltage and torque equations in rotor reference frame variables

Text and Reference Books

1. P.C. Krause, "Analysis of Electric Machinery, McGraw Hill", NY, 1987
2. C.V. Jones, "The unified Theory of Electrical Machines", Butterworth,-London, 1967
3. Stevenson, "Power System Analysis", McGraw Hill, NY
4. Dhar R.N., "Computer Aided Power System Operation and Analysis", Tata McGraw Hill
5. P.S. Bhimbra, "The Generalised Theory of Electrical Machines", Tata McGraw Hill
6. B.Adkins&R.G.Harley, "The General theory of AC Machines", Tata McGraw Hill
7. R. Krishnan, "Electric Motor Drives – Modelling, Analysis and Control", PHI Learning Private Limited, New Delhi, 2011.

Mapping of Course outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1	1	1						2	2
CO2	3	2	1			1		1						2	2
CO3	3	2	1			1		1						2	2
CO4	3	2												2	2
CO5	3	2		1				1						2	2

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based onattendance of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE4019: Solar Thermal and PV Technology (Professional Elective II)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Engineering Physics, Electrical Machines I, Power System I

Course Description:

EE4030 Solar Thermal and PV Technology-This course will introduce the basics of solar Photovoltaic power generation and grid connection issues. This course will also describe thermal applications of solar power.

Course Objectives:

The objectives of the course are to

1.Outline the technologies that are used to harness the power of solar energy
2. Design a stand-alone PV system
3.Understand the physics of solar PV systems and grid connected topologies
4. Understand different types of solar PV cells
5.Outline the different solar thermal technologies

Course Outcomes:

After completing the course, students will able to

CO1.	Determine I-V and P-V Characteristics of Solar cell
CO2	Design the various parameters of stand alone solar pv system
CO3	Understand different grid connected topologies based on isolation and power stages
CO4	Understand different types of solar pv cells
CO5	Understand different solar thermal collectors

UNIT-I	**Introduction to Solar Energy:** Solar Spectrum, Solar Geometry, Sun Earth angles, Solar radiation at given locations, Solar radiation measurement, sun path diagrams Light generated current, I-V & P-V Characteristics of silicon solar cell
UNIT-II	**Solar PV Technology:** Amorphous mono-crystalline, poly-crystalline, Shading impact, PV module, Array, Maximum Power Point Tracking, Standard test conditions, Impacts of temperature and Insolation on I-V curves Design of stand-alone systems
UNIT-III	**Solar PV Grid Integration:** Grid connection principle, Topologies for PV-Grid interface, Isolation, Number of power stages, Convertors based on control dynamics, d-q axis control methodology
UNIT-IV	**Thin film Technology:** Generic advantages of thin film technologies, Materials for thin film technologies, Cadmium Telluride solar cell, Introduction to Organic solar PV cell, Water pumping applications
UNIT-V	**Solar Thermal Technology:** Flat plate collector, Parabolic trough, Central receiver, parabolic dish, Fresnel,

	solar pond, solar still , Single node analysis of flat plate collectors, top loss and bottom loss coefficients

Text Books:

1. Chetan Singh Solanki, " Solar Photovoltaic Fundamentals, Technologies and applications", second edition, PHI Publication
2. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, John Willy and sons,2004,ISBN0-471-28060-7.
3. S. P. Sukhatme and J.K.Nayak“Solar Energy principles of thermal collection and storage”, Tata McGrew Hill, third edition,
4. A ElbasetAdel,"Performance Analysis of Grid-Connected Photovoltaic Power Systems " Lambert Academic Publications

Reference Books:

1.MuhammadSulaman, "Design & Analysis of Grid Connected Photovoltaic System"Lambert Academic Publications
2. Mullic and G.N.Tiwari, “Renewable Energy Applications”, Pearson Publications.
3. John A. Duffie, William A. Beckman, “Solar Engineering of Thermal Processes”, Wiley Inter science Publication, 1991.

Mapping of Course outcome with program outcomes

Corse outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	1	1	1	1	2		1	1			1	3	
CO2	3	2	1	1	1	1	1	1	1	1	1	1	1	3	
CO3	3	1	1	1	1	1	1		1	1	1	1	1	3	
CO4	3	1	1	1	1	1	1	1	1	1	1	1	1	3	
CO5	3	1	1	1	1	1	1	1	1	1	1	1	1	3	

1- LOW 2- MEDIUM 3- HIGH

Teacher’s Assessment: Teacher’s Assessment is based on one of the /or combination of the few of the following.

1. Home Assignments
2. Power point presentation
3. Develop working models
4. Surprise written Test with multiple choice questions
5. Quiz

EE4020: Integrated Analog Circuits (Professional Elective II)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : Nil Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: EE 2003 Analog Electronics
EE 2011 Linear Integrated Circuits and Applications

Course Description :
Integrated Analog Circuits (EE4038) is a one-semester course. The students can opt this course as professional elective course.

Course Objectives:
The objectives of the course are to-
1. Introduce the basic building blocks of voltage regulators
2. Understand analog multiplier circuits and operational transconductance amplifier
3. Make students familiar with various types of power amplifiers
4. Study special function integrated circuits
5. Explain structure and characteristics of advanced operational amplifiers

Course Outcomes :
After completion of this course students will be able to:

CO1. Discuss basics, construction, characteristics, various configurations etc. of voltage regulators
CO2. Explain analog multiplier circuits and operational transconductance amplifier
CO3. Describe various types and applications of power amplifiers
CO4. Discuss special function integrated circuits
CO5. Describe the basics, construction, characteristics of advanced op-amp

Detailed Syllabus:

UNIT-I	**Voltage Regulators:** Basic voltage regulators, Shunt regulator using Op-amp, Series Regulator using Op-amp, IC 723, Protection Circuits in Regulators, Three Terminal Fixed Voltage Regulators, Three Terminal Adjustable Voltage Regulators, Switching Regulators, SMPS
UNIT-II	**Analog Multiplier Circuits:** Analog Voltage Multiplier Circuits, Analog Voltage Divider Circuits, Performance Parameters, Multiplier Applications **Operational Transconductance Amplifier (OTA):** Operating Principle, Bipolar OTA, Equivalent Circuit of OTA, OTA Applications, Building Blocks using OTA
UNIT-III	**Power Amplifiers:** Audio Power Amplifiers, LM380: Features, Pin Diagram, Internal Circuit Diagram, Rating, Electrical Characteristics and Applications of LM380. LM384 Audio Power Amplifier, LM377 Audio Amplifier, IC810 Audio Power Amplifier.
UNIT-IV	**Special Function Integrated Circuits:** Voltage to frequency and Frequency to Voltage Converters, 9400 Series V/F

	and F/V Converters, XR-2206 Function Generator, Integrated Circuit Tuned Amplifier, mVideo Amplifier, Opto-Couplers, Isolation Amplifier, Fiber-Optic Integrated Circuits, Compander Integrated Circuits.
UNIT-V	**Advanced Operational Amplifiers:** Introduction, CMOS Op-amps, BiFET and BiMOS Circuits, JFET Amplifiers

Text books:

1. S. Salivahanan, V. S. Kanchana Bhaskaran, "Linear Integrated Circuits", Tata McGraw-Hall
2. Sanjay Sharma, "Op-Amp and Linear Integrated Circuits", Katson Books

Reference Books:

1. R. A. Gaikwad, "Op-amps and Linear Integrated Circuits Technology", PHI Publications
2. G. B. Clayton, "Operational Amplifiers", Butterworth & Co. Publications
3. K. R. Botkar, "Integrated Circuits", Khanna Publications
4. S. Franco, "Design with Operational Amplifiers and Analog ICs", Tata McGraw-Hall

Mapping of Course outcome with program outcomes (Electrical Engineering):

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	1		1				1	1					3
CO2	3	1			1				1	1					3
CO3	3	1	1		1				1	1					3
CO4	3	1	1		1				1	1					3
CO5	3	1			1					1					3

1. Low 2. Medium 3. High

Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials, NPTEL lectures and home Assignments

Teacher's Assessment:

Teacher's Assessment marks is based on attendance of the student and any one component of the following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1) Multiple Choice Question Test
2) PPT presentation
3) Surprise test
4) Quiz
5) Home assignments

EE4021: Biomedical Instrumentation (Professional Elective II)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 04 Hrs/Week	Class Test I	: 15 Marks
Tutorial	: 00	Class Test II	: 15 Marks
Total Credits	: 04	Teachers' Assessment	: 10 Marks
		End -Semester Exam	: 60 Marks

Pre-Requisites :EE2009:Electrical Measurement & Instrumentation

Course description:

EE4022 Biomedical Instrumentation is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. provide an acquaintance of the physiology of the heart, lung, blood circulation and circulation respiration. Biomedical applications of different transducers used.
2. introduce the student to the various sensing and measurement devices of electrical origin.
3. provide awareness of electrical safety of medical equipments
4. provide the latest ideas on devices of non-electrical devices.
5. bring out the important and modern methods of imaging techniques.
6. provide latest knowledge of medical assistance / techniques and therapeutic

Course Outcomes:

After completing the course, students will be able to:

CO1	Known Physiology and proper transducer for measurement
CO2	Develop set up for measurement of human parameter for measurement
CO3	Select proper transducer for measurement of non electrical
CO4	Analysis medical imaging
CO5	Create a proper therapeutic experiment setup for measurement

Detailed Syllabus:

Unit 1	**PHYSIOLOGY AND TRANSDUCERS** Cell and its structure – Resting and Action Potential – Nervous system: Functional organisation of the nervous system – Structure of nervous system, neurons - synapse – transmitters and neural communication – Cardiovascular system – respiratory system – Basic components of a biomedical system - Transducers – selection criteria – Piezo electric, ultrasonic transducers – Temperature measurements - Fibre optic temperature sensors.
Unit 2	**ELECTRO – PHYSIOLOGICAL MEASUREMENTS** Electrodes –Limb electrodes –floating electrodes – pregelled disposable electrodes - Micro, needle and surface electrodes – Amplifiers: Preamplifiers, differential amplifiers, chopper amplifiers – Isolation amplifier. ECG – EEG – EMG – ERG – Lead systems and recording methods – Typical waveforms. Electrical safety in medical environment: shock hazards – leakage current- Instruments for checking safety parameters of biomedical equipments

Unit 3	**NON-ELECTRICAL PARAMETER MEASUREMENTS** Measurement of blood pressure – Cardiac output – Heart rate – Heart sound – Pulmonary function measurements – spirometer – Photo Plethysmography, Body Plethysmography – Blood Gasanalysers : pH of blood –measurement of blood pCO2, pO2, finger-tip oxymeter - ESR, GSR measurements .
Unit 4	**MEDICAL IMAGING** Radio graphic and fluoroscopic techniques – Computer tomography – MRI – Ultrasonography – Endoscopy – Thermography – Different types of biotelemetry systems and patient monitoring – Introduction to Biometric systems
Unit 5	**ASSISTING AND THERAPEUTIC EQUIPMENTS** Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Heart – Lung machine – Audio meters – Dialysers – Lithotripsy

Text and Reference Books:

1. R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd.,2003.
2. Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, 'Bio-Medical Instrumentation and Measurements', II edition, Pearson Education, 2002 / PHI.
3 M.Arumugam, 'Bio-Medical Instrumentation', Anuradha Agencies, 2003.
4 L.A. Geddes and L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', John Wiley &Sons, 1975.
5. J.Webster, 'Medical Instrumentation', John Wiley & Sons, 1995.
6. C.Rajarao and S.K. Guha, 'Principles of Medical Electronics and Bio-medical Instrumentation',Universities press (India) Ltd, Orient Longman ltd, 2000.

Mapping of Course outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1		1				1			
CO2	3	2		1		1		2				1			
CO3	3	2		1		1		2				1			
CO4	3	2				1	1	1				1			
CO5	3			1				1				1			

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based onattendanceof the student andone of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE 4022: Reliability and Condition Monitoring (Professional Elective II)	
Teaching Scheme Lectures : 04Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites:EE 2008: Electrical Machines-I
EE 3002: Electrical Machines-II

Course Description:

EE 4017 Reliability and Condition Monitoring is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to-

1. Know engineering system monitoring and fault diagnosis and explains the basic concepts of condition monitoring.
2. Know how modern technology, quality control and environmental issues have affected current thinking.
3. Protect themselves and others in the workplace and focuses on the safety measures needed when Carrying out monitoring activities, especially those for isolating equipment.
4 Know how to use a range of condition monitoring equipment and will develop the skills and knowledge required for the location and identification of faults in engineering systems.
5. Learners will be required to select the appropriate monitoring technique and equipment based on the type of plant or equipment being monitored and the conditions checked.

Course Outcomes:

After completing the course, students will be able to:

CO1	Know the health and safety requirements relevant to monitoring and fault diagnosis of engineering Systems.
CO2	Know about system monitoring and reliability.
CO3	Use monitoring and test equipment
CO4	Carry out fault diagnosis on electrical engineering equipment
CO5	Develop model for improvement in life of electrical equipment.

Detailed Syllabus:

Unit 1	**Introduction to the field of machine condition monitoring:** methods, tools used to monitor a machine, diagnostics and prognostics, reliability, maintenance practices, health usage monitoring, Frequency of monitoring, infrared thermography, Ultrasounds
Unit 2	**Failure analysis:** Failure mode-effect and criticality analysis, fault tree analysis. Breakdown mechanisms in gases, liquids, vacuum, solids. maintenance strategies (breakdown, preventive, planned, scheduled, diagnostic, total productive maintenance, reliability centered maintenance) organization for maintenance, maintenance requirements, maintenance planning and work control, maintenance records, frequency of maintenance, cost of maintenance, maintenance effectiveness
Unit 3	**Condition Monitoring of Transformer:** Type of faults, duration and the impacts Interpretation of gases generated in Oil-Immersed Transformer ,Transformer winding and core deformation detection utilizing

	SFRA technique, Methods of Dissolved Gas Analysis (DGA), partial discharge
Unit 4	**Diagnosis of electrical equipment:** Motors, generators, Configuration, problems, diagnosis and solutions, Causes of motor failure, remedies. Signature analysis, condition monitoring of induction motor, power cables
Unit 5	**Substation Maintenance:** Types – Routine, Preventive, Planned, Predictive, Break-down, Emergency maintenance, on-line maintenance of different equipments, Condition monitoring of power apparatus, New advanced techniques in diagnosis and monitoring of electrical equipment.

Text and Reference Books

1. Advances in high voltage engineering, edited by A. Haddad and D. Warne, IEE Power and EnergySeries, 2004.
2. Electrical Insulation in Power Systems, N. H. Malik, A. A. Al-Arainy and M. I. Qureshi, Marcel Dekker,1997.
3. Insulation of High Voltage Equipment, V.Y. Ushakov, Springer-Verlag, 2004.
4. High Voltage Engineering Fundamentals, KuffelZaengelKuffel, Newnes
5. K. B. Raina, S. K. Bhattacharya, Electrical Design, Estimation and costing, wiely eastern limited NewDelhi 1991.
6. S. L. Uppal- Electrical Power- Khanna Publishers Delhi.
7. Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence, W.H. Tang, Q.H. Wu ,ISBN: 978-0-85729-051-9
8. Handbook of Condition Monitoring: Techniques and Methodology Edited by A. Davies
9. Advances in Electrical Engineering and Electrical Machines Editors: DehuaiZheng, ISBN: 978-3- 642-25904-3

Mapping of Course outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1	1	1					2	2	
CO2	3	1				1	1	1					2	2	
CO3	3	1											2	2	
CO4	3	1	1			1		1					2	2	
CO5	3	1						1					2	2	

1- Low 2- Medium 3- High

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized.

EE4023: SMART GRID TECHNOLOGY (Professional Elective II)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites: EE 3004 Power Systems II

Course Description: This course introduces the concepts of smart grid technology & covers the various aspects of smart grid.

Course Objectives: The objectives of the course are to

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understand concept of power quality issues in Smart grid
5. Appreciate problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes : After completing the course, students will able to:

CO1	Explain fundamentals of smart grid
CO2	Describe different smart grid technologies
CO3	Explain the concept of micro grids and distributed energy resources
CO4	Identify the power quality issues in Smart grid
CO5	Compare different communication technologies for Smart Grid

Detailed Syllabus :

Unit 1	Introduction to Smart Grid**:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid
Unit 2	Smart Grid Technologies: Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers. Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit
Unit 3	Micro grids and Distributed Energy Resources: Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar Cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources.
Unit 4	Power Quality Management in Smart Grid:

	Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.
Unit 5	Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Text and Reference Books

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadiere, Nouredine Hadjsaid, "Smart Grids", Wiley Blackwell
5. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7)

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1				2	2	3	2	2		2	3		
CO2	3	1				2	2	3	2	2		2	3	2	2
CO3	3	1				2	2	3	2	2		2	3	2	2
CO4	3	1				2	2	3	2	2		2	3	1	
CO5	3	1				2	2	3	2	2		2	3	2	2

1 – Low 2 – Medium 3 – High

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. MCQ
3. Simulations problems
4. Quiz

EE4024:High Voltage Engineering (Professional Elective III)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites: EE2010 Power System-I

Course Description: This course introduces the concepts of High Voltage Engineering The course contains the basic breakdown theories related to various insulating materials and covers the various aspects of over voltages generation and insulation coordination.

Course Objectives:
The objectives of the course are to

1. develop an understanding of breakdown phenomenon in case of solid, liquid and gaseous insulating medium
2. develop familiarity with various methods of generation of high voltages
3. develop familiarity with various methods of measurement of high voltages
4. develop an understanding of over voltage phenomenon & concepts of insulation coordination
5. develop an understanding of importance of testing of power apparatus

Course Outcomes:
After completing the course, students will able to:

CO1	Calculate breakdown strength of various insulating materials for power system applications
CO2	Describe the breakdown phenomenon in case of various insulating materials
CO3	Explain the concepts of generation of high voltages & currents
CO4	Explain the causes and protection from over-voltages and of insulation coordination
CO5	Explain the direct and indirect testing methods

Detailed Syllabus:

UNIT-1	Conduction & Break Down in Gases: Ionization Process & Current Growth, Townsends Criterion for Break Down, Determination of Alpha & Gamma, Streamer Theory of Break Down in Gases, Paschen's Law, Breakdown in Non-Uniform Field & Corona Discharge. Conduction & Break Down in Pure Liquid & Commercial Liquid--cavitation mechanism, suspended particle mechanism etc.; Breakdown in Solid Dielectrics-intrinsic, electromechanical, thermal breakdown etc.
UNIT-2	Generation of High Voltage & Currents: Generation of High D. C. Voltages: voltage doubler, voltage multiplier, electrostatic machines etc.; Generation of High Alternating Voltages: cascade circuits, resonating circuits etc. Generation of transient voltages: Single stage and multistage impulse generator circuits, tripping and synchronization of impulse generator; Generation of switching surge voltages; Generation of Impulse Currents

UNIT-3	Measurement of High Voltages & Currents: Measurement of High Direct Current Voltages, High Alternating Voltages & Impulse Voltages- use of potential dividers, gaps and other methods of measurement; Measurement of High Direct Currents, High Alternating Currents & High Impulse Currents
UNIT-4	Over Voltage Phenomenon & Insulation Coordination: Natural Causes for Over Voltages, Lightning Phenomenon, Over Voltages Due to Switching Surges, System Faults & Other Abnormal Conditions, Principles of Insulation Coordination on High Voltage & Extra High Voltage Power Systems, concept of statistical factor of safety, risk of failure
UNIT-5	High Voltage Testing of Power Apparatus: High voltage testing of bushings, transformers, cables etc. Non-destructive insulation test techniques: High voltage dielectric loss measurements, discharge measurements

Text and Reference Books:

1. M. S. Naidu , V. Kamaraju, "High Voltage Engineering" , Tata McGraw –Hill publications
2. E. kuffel, W.S. Zaengl, J. Kuffel, "High Voltage Engineering fundamentals", Butterworth – Heinemann publishers
3. D. kind, K. Feser, "High Voltage Test Techniques", Vieweg/ SBA publications
4. M. Khalifa, "High Voltage Engineering- Theory & Practices", Dekker publications

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Po 13	PO 14	PO 15
CO1	3	1				1						1	3		
CO2	3	1				1	1					1	3		
CO3	3	1	1			1	1					1	3		
CO4	3	1				1						1	3		
CO5	3	1				1						1	3		

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following.

1. Assignments
2. MCQ
3. Quiz

EE 4025 : NON LINEAR CONTROL SYSTEMS (Professional Elective III)	
Teaching Scheme Lectures : 4 Hrs/Week Total Credits : 4	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Control systems II

Course description: - The course begins with a review of basic concepts from set theory and then introduces to modeling of simple mechanical systems using Lagrangian formulation, thereby formulating state-space representation of nonlinear ordinary differential equations.

Course objectives: -The objectives of the course are to

1. Review mathematical preliminaries
2. Explain mathematical modeling of system
3. Explain the phase plane portraits
4. Explain various methods for stability analysis
5. Explain various methods to check the stability of system

Course Outcomes:

Students will be able to

CO1. Explain and analyze uniqueness of solution of ODE
CO2. Understand the modeling of system
CO3. Describe phase plane portraits
CO4. Evaluate the stability of system
CO5. Analyze the stability of system

Detailed Syllabus:

UNIT-I	Review of mathematical preliminaries on point-set topology, normed spaces, Lipschitz continuity, existence and uniqueness of solution of ODE's.
UNIT-II	Modeling of simple mechanical systems, degree-of-freedom, configuration spaces and state-space representation, equilibrium points/operating points, Jacobian linearization.
UNIT-III	Notion of vector field, trajectories, vector field plot, phase-plane portrait, positively invariant sets and classification of equilibrium points.
UNIT-IV	Second-order systems, Periodic solution, Bendixson's theorem and Poincare-Bendixson criteria.
UNIT-V	Various notions of stability such as Lyapunov stability, Asymptotic stability, Exponential stability.

TEXT BOOKS:

1. Nonlinear System Analysis: M. Vidyasagar.
2. Nonlinear Systems: H. K. Khalil.

Mapping of Course outcome with program outcomes:

Course outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	1				1	1			1	1	1		1
CO2	3	3	1				1	1			1	1	1		1
CO3	3	3	1				1	1	1		1	1	1		1
CO4	3	2	1			1	1	1	1		1	1	1		1
CO5	3	1	1			1	1	1	1		1	1	1		1

1 -LOW, 2- MEDIUM, 3--HIGH

Teaching Strategies:
The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment: Teacher's Assessment based on one of the /or combination of the few of the following.

1. Multiple choice question
2. PPT presentation

EE4026: Special Machines (Professional Elective III)	
Teaching Scheme: Lectures : 4 Hrs/Week Tutorial : NIL Total Credits : 4	**Examination Scheme:** Class Test I : 15 Marks Class Test II : 15 Marks Teachers Assessment : 10 Marks End Semester Exam : 60 Marks

Course Description:

The objective of this course is to give exposure to the students of various special electrical machines, their operation, control and industrial applications. It also covers performance characteristics, and mathematical analysis of it.

Prerequisites: 1. DC and AC Electrical Machines
2. Engineering Mathematics

Course Objectives:

The objective of the course is to give exposure to the students of
1. Principle of operation, analysis and applications of Servo motors
2. Principle of operation, analysis and applications of Stepper motors
3. Basics, analysis and applications of Switched reluctance motor
4. Performance analysis and use of Brushless DC motor
5. Performance analysis and applications of Linear induction motor

Course Outcomes:

After completing the course, students will able to:

CO1	Explain the operations , analyze the performance of servo motors and identify applications
CO2	Explain the operations, analyze the performance of stepper motor and identify applications
CO3	Describe the operations , analyze the performance of Switched reluctance motor and identify applications
CO4	Analyze and identify the applications of BLDC motor
CO5	Analyze and use LIM for industrial applications

Detailed Syllabus:

Unit 1	**Servo motors:** Introduction, types, principle of operation, construction, characteristics, controllers, applications
Unit 2	**Stepper motors:** Introduction, hybrid stepping motor, different configurations for switching control circuits, Variable reluctance stepping motor, characteristics, areas of applications, 5-phase hybrid stepping motor, 1-phase stepping motor, mathematical analysis of stepping motor
Unit 3	**Switched reluctance motor:** Introduction, principle of operation, design aspects, power converters for SR motors, rotor sensing mechanism and logic controller, torque expression, torque calculations, torque-speed characteristics, applications
Unit 4	**Brushless DC motor:** Construction, principle of operation, sensing and switching logic schemes, drive and power circuits, theoretical and transient analysis, control strategies, applications
Unit 5	**Linear induction motor:**

	Double sided LIM, LIM drive, one side LIM, field analysis, 1-D analysis, transverse edge effects in LIM, solutions for current distribution, applications

Text & Reference Books:

1. Toro V.D, "Electric machines and power systems", Prentice Hall of India, 1985
2. Veinott, "Fractional horse power electric motors", McGraw Hill, 1948
3. K. Venkatraman, " Special Electrical Machines" Orient Black swan/ Universities press , 2008
4. A. E. Fitzergerald, C.Kingsly, S.D.Umas, "Electric Machinery", TMH

Mapping of Course outcome with Program Outcomes

Course Outcome	PO 1	PO 2	P O3	P O4	P O5	PO 6	PO 7	P O8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1		1	1		1	1			1		2	
CO2	3	2	1		1	1		1	1			1		2	
CO3	3	2	2		1	1		1	1			1		2	
CO4	3	2	1		1	1		1	1			1		2	
CO5	3	2	1		1	1		1	1			1		2	

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment:

The teacher's assessment should be based on any ONE ofthe following scheme.

1. Assignments : 10 Marks
2. Objective type test : 10 Marks
3. Modelling of electrical machines using any electrical software : 10 Marks
4. Technical/Industrial visit report / Quiz : 10 Marks

EE4027: Electric Traction (Professional Elective III)	
Teaching Scheme	**Examination Scheme**
Lectures : 04 Hrs/Week	Class Test I : 15 Marks
Tutorial : 00	Class Test II : 15 Marks
Total Credits : 04	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Prerequisites:EE4039:Estimation Testing and Maintenance

Course Description:

EE4031Electric Traction is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. Select proper motor for given load characteristic. Selection of motor based on load characteristic, electrical, mechanical characteristic and service duty.
2. Provides the knowledge of electric traction, ideal requirement of traction motor, operation and control.
3. The impact of electrical characteristic of motor in electric traction system.
4. Knowledge of selection of proper drive for traction
5. Implement recent technology of traction system to Indian railways

Course Outcomes:

After completing the course, students will be able to:

CO1	Apply the knowledge of electrical engineering subjects in different application of industries like manufacturing, maintenance, operation and safety.
CO2	Understand the characteristic of load and selection of derive in industrial sectors.
CO3	Conduct practical and analyze data for proper selection of derive in realistic constrain of load requirement.
CO4	Understand the impact of electrical characteristic of motor in electric traction system.
CO5	Do higher study in the field of modern derives and control and develop traction system for Indian railways

Detailed Syllabus:

Unit 1	**Electric Drives** Type of drives, Nature of load, Section motors, electrical, mechanical , service capacity and rating and Types of Enclosures. Electrical Characteristic: Starting, Operating and running, speed control and braking characteristics of DC motor, three phase induction motor single phase induction motor
Unit 2	**Types of Duties** Type of duty: Continuous, intermittent and short time rating , temperature rise and rating calculations for these duties mechanical features , features of load diagram construction, load equalization & use of flywheel.
Unit 3	**Traction Systems** Requirements of ideal traction system, Systems of track electrification and their comparison, speed time curve, factors affecting on schedule speed, Tractive effort, Factors affecting in energy consumption and specific energy consumption.

Unit 4	**Traction Motors** General features of traction motors, Control of traction motor: starting, speed control and braking of traction motor , Energy returned during regenerative braking ,overhead equipment control gear .
Unit 5	**Recent terminology in traction drives** Analysis and performance characteristics of chopper fed dc motors, Motoring and braking operations, Multiphase chopper, Phase locked loop control of dc drive. Variable voltage variable frequency (VVVF) operation, Voltage source inverter (VSI) fed induction motor drive, Static rotor resistance control, Slip power recovery systems, closed loop control of ac drives, Introduction to field oriented control of ac motors, Recent development in Indian railway traction system technology and its implementation in Indian railways

Text and Reference Books:

1. J.B.Gupta , "A Course in Electrical Power"
2. V.V.L.Rao, "Utilization of Electrical Energy", TMH
3. O.E.Taylor , "Utilization of Electrical Energy", TMH
4. S.K.Pillai, "A Course in Electrical Energy", TMH
5. H. Partab, "Art & Science of Utilization of Electrical Energy"

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1							1	2	1
CO2	3	2	1			1							1	2	1
CO3	3	2				1							1	2	1
CO4	3					1							1	2	1
CO5	3	2		1	1	1							1	2	1

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is **based on attendance** of the student andone of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE4028: Power Plant Engineering (Professional Elective III)	
Teaching Scheme	**Examination Scheme**
Lectures : 04 Hrs/Week	Class Test I : 15 Marks
Tutorial : 00	Class Test II : 15 Marks
Total Credits : 04	Teachers' Assessment : 10 Marks
	End -Semester Exam : 60 Marks

Prerequisites: EE2010 Power System-I

Course description: The development of power engineering proceeds at a rapid pace. Power engineering is the basis for development of all branches of industry. This course explains the design, construction, principle of operation & control of power plants. This course will also make students aware about the probable consequences of the action of power plant on the environment.

Course Objectives: The objectives of the course are to make the students capable of

1. Understand types, principles of operations, components and applications of steam turbine power plants
2. Know the principal components and types of nuclear reactors.
3. Know the principal components and types of **Hydro** power plants
4. Know the basic principles of gas turbine and diesel engine power plants.
5. Understand various terms and factors associated with power plant economics.

Course Outcomes :
After completing the course, students will able to:

CO1	Enlist types, principles of operations, components and applications of steam turbine power plants
CO2	List the principal components and types of nuclear reactors.
CO3	List the principal components and types of **Hydro** power plants
CO4	Describe basic principles of gas turbine and diesel engine power plants.
CO5	Define terms and factors associated with power plant economics.

Detailed Syllabus:

UNIT-1	**Thermal Power Station:** Thermodynamics- Rankine cycle , Carnot cycle; fuels and their handling; combustion processes- fluidized bed combustion; typical layout of power plant; components, working, efficiency of thermal power plant
UNIT-2	**Nuclear Power Plants:** Development of nuclear power plants; elements of a nuclear power station; atomic structure and transformation; Radio-active decay; impact of radio activity and its hazards; the nuclear reactor, fuel, moderator, reflector, coolant, radiation shield; some common types of nuclear reactor
UNIT-3	**Hydro-Electric Plant:** Run off; classification of hydro plants; Components –dam, penstock, surge tank, water turbines, powerhouse; hydrology; pumped storage plants

UNIT-4	**a) Diesel Engine Power Plant:** Field of use, principle of working, types, layout, characteristics **b) Gas Cycle plants: C**omponents; open and closed cycle gas turbines; methods to improve thermal efficiency c) **Non conventional Power Plants:** Introduction to non conventional power plants(solar, wind, geothermal, tidal etc.)
UNIT-5	**Economics of Power Generation:** Location of power plant, load curve, load duration curve, various factors, economics of power station , depreciation, base load and peak load stations, tariff, Indian energy scenario, Basics of major electrical equipments, instrumentation and control and environmental aspects for power plants

Text and Reference Books:

1. M.V. Deshpande, *Elements of Power Station Design*, Tata McGraw-Hill
2. D.H. Bacon, Engineering Thermodynamics, London Butterworth
3. P. K. Nag, Power Plant Engineering-Steam and Nuclear, Tata McGraw Hill
4. Frederick T. Morse, Power Plant Engineering, East West Press Private Limited
5. Mahesh Verma, Power Plant Engineering, Metrepolitan Book Co, Pvt. Ltd.
6. George W. Sutton (Editor), Direct Energy Conversion, Inter University Electronics Series Vol- 3, McGraw-Hill,New York

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3					1	1						1		
CO2	3					1	1						1		
CO3	3					1	1						1		
CO4	3					1	2						1		
CO5	3					3	1						3		1

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Assignments
2. MCQ
3. Quiz

EE 4029: ELECTRIC VEHICLES (Professional Elective III)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites: Nil

Course Description: This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. Various aspects of hybrid and electric vehicles such as their configuration, types of electric machines that can be used, energy storage devices, etc. will be covered in this course.

Course Objectives:

The objectives of the course are to introduce and explain:

1. The concepts of electrical vehicles and their operation.
2. The basic components of the EV and their design.
3. Power converters & energy storage devices for electrical vehicles

Course Outcomes :

After completing the course, students will able to:

CO1	Understand the operation of electrical vehicles.
CO2	Explain Power Converters for Electric and hybrid Vehicles
CO3	Understand the Electrical Machines for Electric and hybrid Vehicles
CO4	Understand the design principles of Electric and hybrid Vehicles
CO5	Understand different Energy Storage options for the Electric and hybrid Vehicles

Detailed Syllabus:

Unit 1	History of electric & hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Dynamics of the electric and hybrid electrical vehicles- motion and dynamic equation for vehicles, Vehicle Power Plant and Transmission Characteristics, Basic Architecture of Hybrid Drive Trains and Analysis of Series Drive Train, Power Flow in HEVs, Torque Coupling and Analysis of Parallel Drive Train, Basic Architecture of Electric Drive Trains
Unit 2	Power Converters- DC-DC converters for EV and HEV applications, DC-AC converters in EV & HEV
Unit 3	AC Electrical Machines for hybrid and Electric Vehicles- Induction motors, Permanent Magnet Motors. SRM motors, their control and applications in EV/HEV
Unit 4	Design of EV/HEV – Principles, Drive cycles and its detail analysis, sizing of electrical machines
Unit 5	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, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text and Reference Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", WIELY USA, 2012.
2. Chris Mi, M. Abdul Masrur& David WenzhongGao, "Hybrid Electric Vehicles: Principles and Applications with practical prespective", WIELY, 2011
3. Electric Cars The Future is Now!: Your Guide to the Cars You Can Buy Now and What the Future Holds, by ArvidsLinde, Veloce Publishing,2010.
4. Abu-Rub, Malinowski and Al-Haddad, "Power Electronics for renewable energy systems, transportation, Industrial Applications", WILEY, 2014.
5. Mehrdad Ehsani, YiminGao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", Second Edition (Power Electronics and Applications Series) by CRC Press, 2009
6. John Miller, " Propulsion Systems for Hybrid Vehicles," Institute of Electrical Engineers, UK, 2004
7. C.M. Jefferson & R.H. Barnard, " Hybrid Vehicle Propulsion," WIT Press, 2002
8. Iqbal Husain, "Electric and Hybrid Vehicles – Design Fundamentals," CRC Press, 2010
9. James Larminie and John Lowry, " Electric Vehicle Technology Explained, " Oxford Brookes University, Oxford, UK, 2003

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	2			2	3	2	2	2		2	2		
CO2	3	1	2			2	3	2	2	2		2		3	2
CO3	3	1	2			2	3	2	2	2		2		3	
CO4	3	2	2			2	3	2	2	2		2			
CO5	3	1	2			2	3	2	2	2		2	2	2	1

1 – Low 2 – Medium 3 – High

Teaching Strategies: The teaching strategy is planed through the lectures, tutorials and team based home Assignments

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course co-rdinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. MCQ
3. Simulations problems
3. Quiz

EE4030: Design of Transformer (Professional Elective III)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites: EE 2008: Electrical Machines-I
EE 3002: Electrical Machines-II

Course description:

EE4028 Design of Transformer is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. Study mmf calculation and thermal rating of various types of electrical machines.
2. Analyze the performance characteristics of transformer
3. Design core, yoke, windings and cooling systems of transformers.
4. Design and analysis of instrument transformer
5. Design all type of transformer by computer programming

Course Outcomes:

After completing the course, students will be able to:

CO1	Understand basic aspects of design criteria of transformer
CO2	Design the transformers of given specifications
CO3	Prepare the detailed sketches of the designed machines
CO4	Design the Instrumentation transformers of given specifications
CO5	Design all types the transformers by using computer programming

Detailed Syllabus:

Unit 1	**GENERAL DESIGN ASPECTS:** Specific electric loading and Specific magnetic loading; Output coefficient; Output equations for transformers and rotating machines; Factors affecting size of machines; Criteria for selection of specific loadings; Heating and Cooling of Transformers and rotating machines.
Unit 2	**DESIGN OF THREE PHASE TRANSFORMER:** Types of transformers; Position of HV and LV windings and its importance; Relation between core and yoke cross section area and its significance; Different types of transformer windings; Different positions of taping; Window space factor; Factors affecting window space factor; Relation between emf per turn and transformer rating; Stacking factor. MAIN DIMENSIONS: Design of window dimensions, yoke dimensions and overall core dimensions; Numerical examples. DESIGN OF WINDINGS: Design of HV and LV windings (No. of turns and area of cross section); Selection of type of winding.
Unit 3	**PERFORMANCE PARAMETERS ESTIMATION:** Primary and secondary winding resistance and Leakage reactance calculation; Calculation of no load current, losses and temperature rise of transformer;Design of tank

	with tubes; Calculation of dimension of tank; Numerical examples. Variation of output and losses in transformer with linear dimensions;
Unit 4	**DESIGN OF SPECIAL TYPE OF TRANSFORMER:** Basic design aspects of dry transformer and high frequency transformers. Basic design aspects of welding transformers and instrument transformers. Design of grounding transformer
Unit 5	**COMPUTER AIDED MACHINE DESIGN** Complete design of all type of single phase and three phase transformers by using computer programming : Numerical examples .

Text and Reference Books

1. Sawhney, A.K., 'A Course in Electrical Machine Design', Dhanpat Rai& Sons, New Delhi, 1984.
2. Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford andIBH Publishing Co. Pvt. Ltd., New Delhi, 1987.
3. A.Shanmugasundaram, G.Gangadharan, R.Palani 'Electrical Machine Design Data Book', New Age Intenational Pvt. Ltd., Reprint 2007

Mapping of Course Outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2						1					1	1	1
CO2	3	2	2			1		1					1	1	1
CO3	3	2	2			1		1					1	1	1
CO4	3	2	2			1		1					1	1	1
CO5	3	2	1		1			1					1	1	1

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized.

EE 4031: Estimation Testing and Maintenance (Professional Elective III)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Course Description: This course aims to give introduction of the basic concepts of estimation and maintenance of Electrical Equipments. It covers testing of various electrical Electrical Equipments, Indian Electricity Rules and different methods of grounding in electrical system.

Prerequisites:EE 1001: Basic Electrical Engineering
EE 2008: Electrical Machines-I
EE 3002: Electrical Machines-II

Course Objective:
The objectives of the course are to give exposure to the students of:

1. Understand different wiring scheme for internal wiring of buildings.
2. Learn various testing for electrical equipments as per IS standard.
3. Study of maintenance schedule for electrical equipments as per IS standard.
4. Understand Indian Electricity Rules 2003
5. Study various methods of Grounding in electrical system.

Course Outcomes:
After completing the course, students will be able to:

CO1	Estimation for wiring industrial, commercial, residential .
CO2	Explain various testing for electrical equipments as per IS standard.
CO3	Discuss maintenance schedule of electrical equipments as per IS standard.
CO4	Discuss Indian Electricity Rules 2003.
CO5	Explain methods of Grounding in electrical system .

Detailed Syllabus:

Unit 1	**Estimation:** Estimation for internal wiring of buildings (residential, commercial and small industry), Service lines, L.T. distribution and street light feeders, 11 kV feeders and sub stations ,Estimation of electrical panel boards, Estimation of street light feeders using cables.
Unit 2	**Testing:** Testing of cables, Distribution transformer, Induction Motor, Synchronous Motor, DC Motor, Instrument transformer as per ISI standard, Testing of insulation.
Unit 3	Maintenance of Electrical Equipments: Routine, Preventive and breakdown maintenance, Main causes of failure of electrical equipments, Factors affecting maintenance schedule, Maintenance schedule for distribution transformer as per I.S. 1886, Maintenance schedule for power transformer as per I.S. 11028, Maintenance schedule for Induction Motor as per I.S. 900,

	Maintenance schedule for Synchronous Motor as per I.S. 4884, Maintenance schedule for storage battery, Maintenance schedule for switchgear and control equipments as per I.S. 3072.
Unit 4	Indian Electricity Rules: Safety precautions, Condition relating to survey and use of energy, Indian Electricity Rules 2003 for safety, Maintenance of equipment, Testing of equipment.
Unit 5	Grounding: Neutral grounding, Solid grounding, Resistance grounding, Reactance grounding, EarthingTransformer .

Text and Reference Books

1. J.B.Gupta, "Transmission and Distribution", S.K.Kataria& sons New Delhi.
2. S.L.Uppal, "Electrical Wiring, Estimation & Costing", Khanna publishers, New Delhi.
3. S.L.Uppal, "Electrical Power", Khanna publication, New Delhi.
4. H.Partab, "Art and Science of Electrical Utilization", DhanpatRai and sons New Delhi.
5. B.D.Arora, "Electrical, Wiring, Estimation and Costing", New Heights New Delhi.
6. N. Alagappan S. Ekambaram, "Electrical Estimating and Costing", Tata McGraw-Hill.
7. Frank J. Oliver, "Practical Relay Circuits", D. B. Taraporewala sons Mumbai.
8. Relevant I.S. Codes Publishing company limited New Delhi.
9. H. Cotton, "The Transmission and Distribution of Electrical Energy", The English Language Book Society.
10. M. G. Say," The Performance and Design of Alternating Current Machines", CBS Publishers & Distributors.

Mapping of Course outcome with Program Outcomes :

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2	1				1	1					1		
CO2	3	2	2				1	1					1		
CO3	3	2					1	1					1		
CO4	3	2					1	1					1		
CO5	3	2	1					1					1		

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on **attendance** of the student and one of following.

1.Assignments : 10 Marks
2.MCQ test. : 10 Marks
3.Presentation on latest topics/Real life problems related with the subject : 10 Marks
4. Quiz : 10 Marks

EE 4032 : ADVANCED SWITCHGEAR AND PROTECTION (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Total Credit : 04	**Examination Scheme** Test 1 : 15 Marks Test 2 : 15 Marks Teachers Assessment : 10 Marks End Semester Exam : 60 Marks

Prerequisites:

EE 3004: Power System –II
EE 3010: Switchgear and Protection
EE 3014: Advanced Power System

Course Description: This course is a one-semester course as an elective to fourth year Electrical Engineering students. It is the advance course related to power system protection.

Course Objectives: The objectives of the course are to introduce & explain:

1. Arc interruption theories & switching transients under different switching operations
2. Design aspects & testing of circuit breakers
3. Principle & operation of different static relays.
4. Aspects of digital protection.
5. Concepts of GIS & embedded protection of power systems.

Course Outcomes: After completing the course, students will be able to:

CO1	Understand arc interruption theories & switching transients under different switching operations
CO2	Understand the design aspects of vacuum circuit breakers & standard testing of circuit breakers
CO3	Explain principle & operation of different static relays
CO4	Understand the fundamentals of numerical relaying
CO5	Describe concepts of GIS & embedded protection of power systems

Detailed Syllabus:

Unit 1	Arc Interruption Theories: The details study of – Slepian's theory, Prince's theory's, Cassies theory's, Mayr's theory, Browne's combined theory Switching Transients: Closing of a line, Reclosing of a line, Interruption of small capacitive currents, Interruption of Inductive load currents, Current chopping, Interruption of short line fault, Traveling waves : Velocity and characteristic impedance, Energy contents of Traveling waves, Reflection and Refraction of Traveling waves
Unit 2	Design of Circuit Breakers: Standards of Circuit Breakers, Design aspect of Vacuum Interrupters, contact shape and size, contact material, contact travel. Time-travel characteristics of moving contact of Vacuum circuit breaker, Contact Pressure, Contact Erosion Testing of Circuit Breakers :Introduction, Classification, Description of a simple testing station, Equipment used in the station, Testing procedure, Direct testing, Test report, Indirect testing
Unit 3	Static Relays: (i) Static Over Current Relays: Instantaneous over current relay, definite time over current relay, inverse-time over current relay, directional over current relay. (ii) Static Differential Relays: Differential relay scheme, single phase static comparator,

	poly phase differential protection. Differential protection for generator and transformer. (i) Static Distance Relays: Impedance relay, reactance relay and mho relay using amplitude and phase comparators. Protection of EHV lines against short circuit and over voltages. Distance and carrier aided schemes.
Unit 4	Digital Protection: Philosophy of Numerical relaying: Characteristics - Functional Diagrams - Architecture and algorithms -Anti –aliasing Filters, sampling, Measurements principles using Fourier and other algorithms and its application for implementation of various numerical relays. SCADA based protection systems
Unit 5	**a)** Design and Construction of GIS Station Introduction - Rating of GIS components - Design Features - Estimation of different types of Electrical Stresses -Design Aspects of GIS components - Insulation Design for Components -Insulation Design for GIS - Thermal Considerations in the Design of GIS - Effect of very Fast Transient Over-voltages (VFTO) on the GIS design - Insulation Coordination systems – Gas handling and Monitoring System Design. **b)** Embedded protection systems: General architecture & Essential requirements of an embedded protection system – metering, protection, automation and control modules; model/component based approach in designing an embedded system

Text and Reference Books

1. B. Ravindranath , M. Chander, “Power system protection and switchgear”, New Age International Ltd.
2. Y.G.Paithankar, “Transmission Network Protection: Theory and Practice”, CRC press.
3. Y.G. Paithankar& S. R. Bhide, “Fundamentals of Power System Protection” PHI
4. T. S. MadhavRao, “Power System Protection Static Relays with Microprocessor Applications” TMH 2nd Edition
5. C. Russell, “Switchgear : The art and science of Protective Relaying”, Mason Wiley Eastern Ltd.
6. L. P. Sing, “Digital Protection : Protective Relaying from Electromechanical to Microprocessor”, John Wiley and Sons Ltd**.**
7. Handbook of Switchgears, Bharath Heavy Electricals.
8. Dr. Khedkar M K, Dr. Dhole G M, “A Textbook of Electric Power Distribution Automation”, University Science Press, Delhi, Laxmi Publications, 2010.
9. Arun G. Phadke, James S. Thorp, “Computer Relaying for Power Systems”, Marcel Dekker, Inc.
10. Wright. A. and Christopoulos.C, “Electrical Power System Protection”, Chapman & Hall, 1993.

Mapping of Course Outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				3		3	3	3		3	3		
CO2	3	2	1			3		3	3	3		3	3		
CO3	3	2				3		3	3	3		3	3	2	2
CO4	3	2	1			3		3	3	3		3	3	2	2
CO5	3	2				3	2	3	3	3		3	3		2

1 – Low 2 – Medium 3 – High

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies: The teaching strategy is planed through the lectures, tutorials and team based home Assignments.

EE4033: ADVANCED INSTRUMENTATION (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites:EE2009:Electrical Measurement & Instrumentation

Course Description:

EE4021Advanced Instrumentation is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. Make the students review the instruments used for measurement of basic process parameters like level, flow, pressure and temperature.
2. Explore the various types of analyzers used in industrial applications.
3. Make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques
4. Make students familiarize with Instrumentation standards such as BS1042, ISA 75, ISA 84 and ISA 88.
5. Process Flow diagrams, Instrument Loop diagrams, Instrument Hookup diagrams and Piping and Instrumentation Diagrams.

Course Outcomes:

After completing the course, students will be able to:

CO1	Review the instruments used for measurement
CO2	Know various types of analyzers used in industrial applications
CO3	Familiarize with Instrumentation standards
CO4	Setup experimental procedure and equipment for measurement of parameter as per standards
CO5	Improve the measurement criteria for electrical and Mechanical quantity

Detailed Syllabus:

Unit 1	**Spectrophotometric /Gas Analysers** IR/NIR/UV/VIS Analysers – Cells, Detectors, Signal Processing, Calibration, Minimization of Interference and Comparative Analysis of Analysers& Gaseous Components Detected Hydrocarbon Analysers - Flame Ionisation Detectors, Principle of Operation Oxygen and NO/NO2 Analysers - Signal Processing, Calibration, Minimization of Interference, Applications Sampling Systems – Desirable Features, Filters, Flow and Pressure regulators, Coolers, Condensers, Vacuum Pumps, Blowback Cleaning System, Exhaust Practices.
Unit 2	**Electrochemical/Liquid Analyzers** pH Analyzers – Measurement and Compensation, Pre-amplifiers, Transmitters, Measurement cells. Conductivity Analyzer – Cells and Cell Constant, Effect of temperature on measurement calibration, acid and alkali titration measurement. Redox Analyzer - Principle of operation, components of analyzers and applications.

	Trace Oxygen and Residual Chlorine Analyzer - Principle of operation, components of analyzers and applications.
Unit 3	**Compositional Process Analyzer** Gas and Liquid Chromatography – columns, gas and liquid detectors, data processing, process chromatograph, calibration and application. Mass Spectrometry – Components, different types, sampling systems, calibration and applications
Unit 4	**Biomedical Spectroscopy** Types of Biomolecules, different spectroscopic analysis techniques, principle of operation, components, dataprocessing and applications, Blood gas analyzers
Unit 5	**Advance Instrumentation** Radiochemical Instruments and Nuclear Pulse SpectroscopyRadiation detectors – principle of operation, constructional details, calibration and applications Nuclear Spectroscopy – Instrumentation techniques, signal processing and electronics of nuclear spectroscopy, Pulse height analyser and various nuclear detectors.

Text and Reference Books

1. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", Butterworth Hieneman, Boston, 1995.
2. D.M. Considine, "Process Instruments and Control Handbook", 4th **edition**, McGraw Hill New York, 1993.
3. K. J. Clevett, "Process Analyzer Technology", John Wiley & Sons, 1986, New York.
4. Gas Analysis – Book 14 Fisher Rosemount Educational Services.
5. G. K. Macmillan, "pH Measurement and Control", ISA 1994.
6. pH and Conductivity – Book 13 FisherRosemount Educational Services.
7. R.E. Sherman, "Analytical Instrumentation", TWI Press, Indiana, 1996.
8. Meyers, "Encyclopedia ofAnalytical Chemistry".
9. Instruction Manuals at http:// www.frco.com/proanalytic/library/publicmanuals.htm

Mapping of Course outcome with Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2						1							2
CO2	3	2	1												2
CO3	2	2	1					1							2
CO4	3	2						1							2
CO5	3	2						1							2

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teachers Assessment of 10 marks is based on attendance of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE 4034: Advanced Power Electronics (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Prerequisites:EE3012–Power Electronics

Course Description:
Advanced Power Electronics(EE4026) is a one-semester course. The students can opt this course as professional elective course.

Course Objectives:
The objectives of the course are to-
1. Introduce advanced power semiconductor devices
2. Understand operation of DC to DC converters
3. Study and analyze DC-AC converters
4. Study and analyze AC-AC converters
5. Study power supplies and protection circuits

Course Outcomes:
After completing the course, students will able to:

CO1	Describe structure, characteristics, and applications of advanced power semiconductor devices
CO2	Explain and analyze DC-DC converters
CO3	Explain and analyze DC-AC converters and various control techniques
CO4	Explain and analyze AC-AC converters
CO5	Discuss types of power supplies, protection circuits and thermal modeling

Detailed Syllabus:

Unit 1	**Power Semiconductor Devices:** Power semiconductor devices: Thyristors, Triac, GTOs, switching characteristics, BJT, power MOSFET, SIT, IGBT, MOS controlled thyristors (MCT), IGCT, large band gap materials, PIC
Unit 2	**DC to DC Converter:** Classification of choppers, Principle of operation, Steady-state analysis of class A chopper, step-up chopper, Switching mode regulators: Buck, Boost, Buck-Boost, Cuck regulators, Current commutated and voltage commutated choppers
Unit 3	**DC-AC Converters:** Review of series and parallel inverters, Single phase voltage source inverter, steady state analysis, Half bridge and full bridge inverter: Mc Murray and modified Mc Murray Bedford inverter, voltage control in single phase inverters, PWM inverter, reduction in harmonics, current source inverter, three phase bridge inverter.
Unit 4	**AC-AC Converters:** Classification, principle of operation of step up and step down cycloconverter, single phase to single phase cycloconverter with resistive and inductive load, three phase to single phase cycloconverter: half wave and full wave, cosine wave crossing technique, three phase to three phase cycloconverter

Unit 5	**Power Supplies:** DC power supplies, AC power supplies, multistage converters, control circuits, magnetic design consideration, protection of devices and circuits, thermal modeling of power switching devices, voltage protection, current protection, electromagnetic interference

Text and Reference Books:

1. M.H. Rashid, “Power Electronics: Circuit, Devices and Applications”, PHI
2. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications and Design”, John Willey & Sons.
3. Jacob, Michael, "Power Electronics: Principles and Applications”, Vikas Publishing House
4. C. W. Lander, “Power Electronics”, Tata McGraw-Hill
5. P.C. Sen, “Power Electronics", Tata McGraw-Hill Publications India
6. M.Ramamoorthy, ”An Introduction to Thyristors& Their Applications”, East-West Press Pvt. Ltd., New Delhi

Mapping of Course Outcome with Program Outcomes:

Course Outcome	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PO 13**	**PO 14**	**PO 15**
CO1	3	1				2	1	1	1					3	
CO2	3	1				2	1	1	1					3	1
CO3	3	1				2	1	1	1					3	1
CO4	3	1				2	1	1	1					3	1
CO5	3	1				2	1	1	1					3	1

1- LOW 2- MEDIUM 3- HIGH

Teacher’s Assessment:

Teacher assessment will be based on any one of the following:

1. Multiple Choice Objective Test
2. Assignments/PPT presentation on allotted topics
3. Written Test on numerical

EE4035 : Grid integration of Renewable (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 0 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Engineering Physics, Electrical Machines, Power Systems

Course Description:
In this curriculum, students will be explored to Integration of Renewable Energy Technologiessuch as Wind energy, Solar energy.

Course Objectives:
The objectives of the course are to learn
1. Need of grid integration
2. Various co-generation systems
3. Various solar pv technologies and its integration to grid
4. Grid integration of tidal power plants
5. Grid integration of wind energy systems and its associated issues

Course Outcomes:
After completing the course, students will able to

CO1.	Elaborate necessity of grid integration with renewable sources
CO2	Explain various co-generation systems
CO3	Describe various solar PV technologies and its Integration
CO4	Discuss grid connection of tidal power plants
CO5	Explain grid integration of wind energy systems and its associated issues

Detailed Syllabus:

UNIT-I	**Distributed Generation:** Different types of energy sources- solar, wind, tidal, geothermal, Fuel cell, Concentrated solar thermal, Concept of co-generation, Necessisity of Grid connection, present standards for grid integration
UNIT-II	**Bio-Energy in India:** Bagasse based power generation, synchronization methods, Promotional policies of Govt. of India, Problems associated with bagasse based co-generation
UNIT-III	**Solar PV Technology:** Grid connection principle, Topologies for PV-Grid interface, Isolation, Number of power stages, Convertors based on control dynamics, d-q axis control methodology, Roof-top grid connected systems, Standards for grid connection
UNIT-IV	**Grid Integration of Tidal power plants:** Single basin and double basin tidal power plants, Horizontal-axis axial and Vertical-axis cross flow turbines, Advantages and Limitations of grid connected tidal power plants
UNIT-V	**Grid Integration of Wind Energy:** Wind farms, real and reactive power regulation, voltage and frequency operating limits, wind farm behavior during grid disturbances, power system interconnection, Economic aspects

Text and Reference Books:

1. Thomas Ackermann, Editor, “Wind Power in Power Systems”, John Willy and sons ltd., 2005,ISBN 0- 470-85508-8.
2. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, John Willy and sons,2004,ISBN0-471-28060-7.
3. A Elbaset Adel," Performance Analysis of Grid-Connected Photovoltaic Power Systems " Lambert Academic Publications
4. Chetan Singh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI- second edition, 2011.
5. Siegfried Heier, “Grid integration of wind energy conversion systems” John Willy and sons ltd. 2006.
6. Muhammad Sulaman, "Design & Analysis of Grid Connected PhotovoltaicSystem"Lambert Academic Publications
7. Antonio Moreno-Munoz, "Large Scale Grid Integration of Renewable Energy Sources" IET Publications

Mapping of Course Outcome with Program Outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	1	1	1	1	1	1	1	1	1	1	1	1	3	
CO2	3	1	1	1	1	1	2	1	1	1	1	1	1	3	
CO3	3	1	1	1	1	1	2	1	1	1	1	1	1	3	
CO4	3	1	1	1	1	1	1	1	1	1	1	1	1	3	
CO5	3	1	1	1	1	1	2	1	1	1	1	1	1	3	

1- LOW 2- MEDIUM 3- HIGH

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K1toK6	K1 to K6	K1toK6
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test (30 Marks)	8	7	8	7	
Teachers Assessment (10 Marks)	2	2	2	2	2
ESE Assessment (60 Marks)	12	12	12	12	12

Teacher’s Assessment: Teacher’s Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. multiple choice questions test
4. Quiz

EE 4036 :Utilization of Electrical Energy (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15Marks Class Test II : 15Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Basics of Electrical Engineering, Power systems, Electrical Machines

Course description:

Course Objectives:

The objectives of the course are to

1. Understand laws of illumination and different lighting schemes
2. Understand different heating methods employed in various industries such as steel, wood and plastic, different types welding methods used in industries, at construction sites and domestic purposes as well
3. Define Electrolytic processes
4. Understand existing traction systems in India
5. Understand different services such as urban, sub-urban and mainline rail traffic

Course Outcomes:

After completing the course, students will able to

CO1.	Explain laws of illumination and different lighting schemes
CO2	Explain different heating methods employed in various industries such as steel, wood and plastic, different types welding methods used in industries, at construction sites and domestic purposes as well
CO3	Explain Electrolytic processes
CO4	Explain existing traction systems in India
CO5	Explain different services such as urban, sub-urban and mainline rail traffic

UNIT-I	Illumination: Introduction, Definition, Laws of illumination, Polar curves, Photometry, Artificial sources of light ,Incandescent lamps, Arc lamps, Discharge lamps, Lighting scheme, Street lighting, Factory lighting, Flood lighting.
UNIT-II	Electrical Heating & Welding: Electrical Heating**:** Introduction, Advantages, Modes of transfer of heat, Methods of electrical heating, Resistance heating, Induction heating, Dielectric heating, High frequency heating, Causes of feeler of heating elements. Electric Welding: Introduction, Advantages, Disadvantages of welding, Resistance welding, Electric arc welding, Choice of welding time, Submerge arc welding, Electron beam welding, Laser beam welding, Types of welding electrodes, Comparison between resistance & arc welding, Electrical welding equipment, between AC & DC welding.
UNIT-III	Electrolytic Process: Introduction, Principle of electrolysis, Laws of electrolysis, Various terms related to electrolytic process, Application of electrolytic process, Power supply for electrolysis process.

UNIT-IV	Electrical Traction I : Introduction, Heavy of existing electrical traction system in India, System of traction, System of track electrification, Comparison between DC & AC traction, Special features of traction motors, Different type of traction motor, Braking, Overhead & auxiliary equipment.
UNIT-V	Electrical Traction II **:** Introduction, Types of services, Speed time & speed distance curves for different services, Definition crest speed, Average speed, Schedule time, Dead weight, Accelerating weight, Adhesive weight, Coefficient of adhesion. Factors affecting schedule speed of train, Traction efforts, and specific energy conservation.

Text and Reference Books:

1. Jack L. Lindsey, "Applied Illumination Engineering", Second Edition, The Fairmont Press Publishers
2. C. L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", 10th Edition, New Academic Science Publishers
3. S.V.Suryanarayana, "Utilization of Electric Power Electric Traction", New Age International Publisher
4. R. K. Rajput, "Utilization of Electrical Power", Laxmi Publications
5. E. O. Taylor, "Utilization of Electric Energy", SI Edition, Orient Longman Private Limited,2006

Mapping of Course Outcome with Program Outcomes :

Corse outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	2				1						1	1		
CO2	3	2				2						1	1	1	
CO3	3	2				2						1	1	1	
CO4	3	2				2						1	1	1	
CO5	3	2				2						1	1	1	

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teacher's Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. Multiple choice questions test
4. Quiz

EE4037 : Energy Conservation and Management (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Electrical Machines, Power systems, Utilization of Electrical Energy, Estimation Testing and maintenance

Course description:
The course is prepared to provide detailed understanding of energy conservation and management, Energy, Economics and Environment and their interaction, energy audit and financial management.

Course objectives:
The objectives of the course are
1. Describe the challenges associated with commercial and non-commercial energy
2. Understand the basic knowledge of different terms and principles of energy conservation audit and management and to prepare energy audit report
3. Calculate the simple pay-back period of ENCON opportunities
4. Understand the efficient electricity utilization and identify energy saving potential
5.Understand the efficient heat utilization and identify energy saving potential

Course outcomes:
After completing the course, students will able to

CO1.	Differentiate between commercial and non-commercial energy
CO2	Demonstrate the knowledge of energy conservation and energy audit
CO3	Understand the financial aspects of energy conservation opportunities
CO4	Evaluate the energy saving and conservation in different electrical systems
CO5	Evaluate the energy saving and conservation in different thermal systems

UNIT-I	**Energy Scenario:** Energy sources-primary and secondary, commercial and non-commercial, energy scenario in India and global scenario, Energy security, energy and GDP, energy intensity, energy conservation and its importance, energy conservation Act 2001 and related policies, role of non-conventional and renewable energy
UNIT-II	Energy Audit: Strategy of energy audit, detailed and walkthrough energy audit, comparison with standards, considerations in implementing energy with conservations programmes, instruments for energy audit, energy audit of illumination system, energy audit of electrical systems, energy audit of heating ventilation and air conditioning systems, energy audit of compressed air system, energy audit of building, energy audit of thermal systems, distribution and utilization systems, economic analysis, bench marking, energy conservation Act 2003
UNIT-III	**Financial Analysis and Management:** Investment need, financial analysis techniques, calculation of simple pay-back period, return on investment, cash flows, risk and sensitivity analysis, time value of money, net present value, breakeven analysis, cost optimization, cost and price of energy services, cost of energy generated through distributed generation

UNIT-IV	**Energy efficiency in Electrical Utility:** Losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.
UNIT-V	**Energy Efficiency in Thermal Utility:** Compressed air systems: Types of air compressors, compressor efficiency, efficient compressor operation, compressed air systems component, capacity assessment, leakage test, factors affecting the performance and saving opportunities, HVAC and refrigeration systems, vapour compression refrigeration cycle refrigerants, coefficient of performance, capacity factors affecting refrigeration and air conditioning systems, performance and saving opportunities, vapour absorption refrigeration systems, principle types, saving potential, fan and blowers, types, performance evaluation Types of captive power plants, Cogeneration-Cogeneration technologies, industries suitable for cogeneration

Text and Reference Books:

1. Guide books for National Certification Examination for Energy Manager/ Energy Auditors Book-1, General Aspects, Book-2 Thermal Utilities, Book-3 Electrical Utilities, Book-4.
2. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press
3. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
4. Carbon Capture and Sequestration: Integrating Technology, Monitoring and Regulation edited by E J Wilson and D Gerard, Blackwell Publishing
5. Heating and Cooling of Buildings- Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994
6. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)
7. B. E. Kushare "Handbook on Energy Efficient Motors", International Copper promotion counsel (India).

Mapping of Course outcome with program outcomes :

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3		1	1	1	1	2	1	1	1	1		1	2	
CO2	3	2	1	1	1	1	2	1	1	1	1	1	1	2	
CO3	3	1	1	1	1	2	1	1	1	1	2	1	1	1	
CO4	3	1	1	1	1	1	1	1	2	1	1	1	1	1	
CO5	3	1	1	1	1	1	1	1	2	1	1	1	1	1	

1- LOW 2- MEDIUM 3- HIGH

Teacher's Assessment: Teacher's Assessment is based on one of the /or combination of the few of the following.

1. Assignments
2. Models/ Presentations
3. Multiple choice questions test
4. Quiz

EE4038 : Wind Energy Systems (Professional Elective IV)	
Teaching Scheme Lectures : 04 Hrs/Week Tutorial : 00 Total Credits : 04	**Examination Scheme** Class Test I : 15 Marks Class Test II : 15 Marks Teachers' Assessment : 10 Marks End -Semester Exam : 60 Marks

Pre-requisites: Engineering Physics, Electrical Machines, Power Systems

Course Description:
In this curriculum, students will be explored to Wind Energy Technologies

Course Objectives:
The objectives of the course are to
1. Calculate and analyze wind resource and energy production for a wind turbine from wind speed distribution, wind shear and power curve
2. Describe Weibull and Rayleigh statistics
3. Understand different types of generators in association with wind turbines
4. Describe different control methods for wind turbines
5. Grid integration of wind energy systems and its associated issues

Course Outcomes:
After completing the course, students will able to

CO1	Analyze wind resources and energy production from wind turbines
CO2	Calculate annual energy using Weibull and Rayleigh statistics
CO3	Select different generators for a particular wind turbine
CO4	Discuss wind energy technologies and explain its control
CO5	Explain grid integration of wind energy systems and its associated issues

UNIT-I	**Basics of Wind Energy:** Historical development of wind turbines, wind energy fundamentals, wind turbine aerodynamics, wind speeds and scales, terrain, roughness, power content, atmospheric boundary layer turbulence Wind measurements, devices for measurements, analysis and energy estimates, Betz's limit
UNIT-II	**Wind Power Probability:** Discrete wind histograms, Wind power Probability density function, Weibull and Rayleigh statistics, Average power in the wind, estimates of wind turbine energy, annual energy calculations, Wake effect in wind farms, capacity factor, impact of tower height
UNIT-III	**Wind Turbine Generators:** Synchronous generator, Induction generator, speed control for maximum power, importance of variable rotor speeds, pole changing induction generators, variable slip induction generators, idealized wind turbine power curve
UNIT-IV	**Wind Energy Technology:** Tip speed ratio, stall and pitch control, wind generator topologies, voltage and reactive power control, power quality standard for wind turbines
UNIT-V	**Grid Integration of Wind Energy:** Wind farms, real and reactive power regulation, voltage and frequency operating

	limits, wind farm behavior during grid disturbances, grid synchronization system, Economic aspects

Text and Reference Books:

1. Thomas Ackermann, Editor, "Wind Power in Power Systems", John Willy and sons ltd., 2005,ISBN 0- 470-85508-8.
2. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Willy and sons,2004,ISBN0-471-28060-7.
3. Siegfried Heier, "Grid integration of wind energy conversion systems" John Willy and sons ltd.2006.
4. Fresis L. L., Wind Energy Conversion Systems, Prentice Hall, 1990.
5. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
6. Mathew Sathyajith, Geetha Susan Philip, Advances in Wind Energy Conversion Technology, Springer, 2011.

Mapping of Course outcome with program outcomes:

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3		1	1	1	1	2	1	1	1	1		1	2	
CO2	3	2	1	1	1	1	2	1	1	1	1	1	1	2	
CO3	3	1	1	1	1	2	1	1	1	1	2	1	1	1	
CO4	3	1	1	1	1	1	1	1	2	1	1	1	1	1	
CO5	3	1	1	1	1	1	1	1	2	1	1	1	1	1	

1- 1- LOW 2- MEDIUM 3- HIGH

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K1 to K6	K1 to K6
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 30 Marks	8	7	8	7	
Teachers Assessment 10 Marks	2	2	2	2	2
ESE Assessment 60 Marks	12	12	12	12	12

Teacher's Assessment:

Teacher's Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. multiple choice questions test
4. Quiz

EE 4039: Applications of Power Electronics A (Self Study) (Professional Elective V)	
Teaching Scheme: Lectures : 4 Hrs/Week Tutorial : NIL Total Credits : 04	**Examination Scheme:** Class Test I : 15 Marks Class Test II : 15 Marks Teachers Assessment : 10 Marks End Semester Exam : 60 Marks

COURSE DESCRIPTION:

The objective of this course is to motivate the students to self study the application of power electronics in continuation with the fundamentals and power electronics circuits studied in their previous year. Students are expected to learn power converters, power supplies used in industries, applications of power electronics in utility systems, renewable energy systems and industries.

Prerequisites: 1. Power Electronics

Course Objectives: The objective of the course is to give exposure to the students based on self learning basis of

1. Advanced power converters used in industries
2. Power supplies used in industries
3. Applications of PE in utility systems
4. Applications of PE in Industries
5. Applications of PE in renewable energy systems

Course Outcomes: After completing the course, students will able to:

CO1	Describe and analyse the operations of power converters
CO2	Describe and analyze power supplies used in industries
CO3	Discuss and understand the requirement of power electronics in utility systems
CO4	Identify and discuss use of power electronics in industries
CO5	Identify and discuss use of power electronics in renewable energy systems

Detailed Syllabus: I

Unit 1	Power Converters : • Switching mode regulators: Buck, Boost, Buck-Boost, Cuk • Resonant Pulse Inverters- Series, parallel, voltage control, ZCS resonant converter, comparison between ZCS & ZVS • Multilevel Inverters- Concept, Types, Principle of operation, Applications
Unit 2	Power Supplies: • DC power supplies • AC power supplies • Multistage power supplies • Control Circuits • UPS systems
Unit 3	Applications of PE in Utility Systems: • HVDC, excitation systems, VAR Compensation, static Circuit Breakers, Smart Grids etc.
Unit 5	Applications of PE in Renewable Energy Systems

Text and Reference Books:

1. M.H. Rashid, “Power Electronics”, Third Edition, Prentice-Hall of India Pvt. Ltd. 2005
2. B. K. Bose, “Modern Power Electronics and AC Drives”, Prentice-Hall of India Pvt. Ltd. 2006
3. P.C. Sen, “Power Electronics", Tata McGraw-Hill Publications India
4. M. Ramamoorthy, ”An Introduction to Thyristors & Their Applications”, East-West Press Pvt. Ltd., New Delhi
5. Online open source material

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PO 13	PO 14	PO 15
CO1	3	3	1	2	2	3	2	3	3	3		3		3	
CO2	3	3	1	2	2	3	2	3	3	3		3		3	
CO3	3	3	1	1	1	3	2	3	3	3		3		3	
CO4	3	3	1	1	1	3	2	3	3	3		3		3	
CO5	3	3	1	1	1	3	2	3	3	3		3		3	

1 – Low 2 – Medium 3 – High

Teacher’s Assessment:

Teacher assessment will be based on **any ONE** of the following:

1. Multiple Choice Question Test : 10 Marks
2. Assignments/PPT presentation on allotted topics : 10 Marks
3. Quiz : 10 Marks
4. Mini project (Hardware/Software based) : 10 Marks

EE 4040 : Applications of Power Electronics B (Self Study) (Professional Elective V)	
Teaching Scheme: Lectures : 04 Hrs/Week Tutorial : NIL Total Credits : 04	**Examination Scheme:** Class Test I : 15 Marks Class Test II : 15 Marks Teachers Assessment : 10 Marks End Semester Exam : 60 Marks

Course Description:

The objective of this course is to motivate the students to self study the application of power electronics in continuation with the fundamentals and power electronics circuits studied in their previous courses. Students are expected to learn power converters, power supplies used in industries, applications of power electronics in Automotive, Traction, Defense, Aerospace and Industries.

Prerequisites:

1. Power Electronics

Course Objectives:

The objective of the course is to give exposure to the students based on self learning basis of

1. Advanced power converters used in industries
2. Power supplies used in industries
3. Applications of PE in Automotive and Traction
4. Applications of PE in Industries
5. Applications of PE in Defence and Aerospace

Course Outcomes:

After completing the course, students will able to:

CO1	Describe and analyze the operations of power converters
CO2	Describe and analyze power supplies used in industries
CO3	Discuss and understand the requirement of power electronics in automotive and traction applications
CO4	Identify and discuss use of power electronics in industries
CO5	Identify and discuss use of power electronics in defence and aerospace sector

Detailed Syllabus: I

Unit 1	Power Converters : • Switching mode regulators: Buck, Boost, Buck-Boost, Cuk • Resonant Pulse Inverters- Series, parallel, voltage control, ZCS resonant converter, comparison between ZCS & ZVS • Multilevel Inverters- Concept, Types, Principle of operation, Applications
Unit 2	Power Supplies: • DC power supplies • AC power supplies • Multistage power supplies • Control Circuits • UPS systems
Unit 3	Applications of PE in Automotive and Traction: Battery chargers, Electric vehicles, electric locomotive, trolley buses, subways, automotive electronics, etc.

Unit 4	Applications of PE in Industries: Rolling mills, textile mills, cement mills, compressors, pumps, fans, blowers, elevators, rotary kilns etc.
Unit 5	Applications of PE in Defence and Aerospace

Text and Reference Books:

1. M.H. Rashid, “Power Electronics”, Third Edition, Prentice-Hall of India Pvt. Ltd. 2005
2. B. K. Bose, “Modern Power Electronics and AC Drives”, Prentice-Hall of India Pvt. Ltd. 2006
3. P.C. Sen, “Power Electronics", Tata McGraw-Hill Publications India
4. M. Ramamoorthy, ”An Introduction to Thyristors & Their Applications”, East-West Press Pvt. Ltd., New Delhi
5. Online open source material

Mapping of Course outcome with Program Outcomes:

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
CO1	3	3	1	2	2	3	2	3	3	3		3		3	
CO2	3	3	1	2	2	3	2	3	3	3		3		3	
CO3	3	3	1	1	1	3	2	3	3	3		3		3	
CO4	3	3	1	1	1	3	2	3	3	3		3		3	
CO5	3	3	1	1	1	3	2	3	3	3		3		3	

1 – Low 2 – Medium 3 – High

Teacher’s Assessment:

Teacher assessment will be based on **any ONE** of the following:

1. Multiple Choice Question Test : 10 Marks
2. Assignments/PPT presentation on allotted topics : 10 Marks
3. Quiz : 10 Marks
4. Mini project (Hardware/Software) : 10 Marks