ACADEMIC REGULATIONS
COURSE STRUCTURE
AND
DETAILED SYLLABUS

ELECTRICAL AND ELECTRONICS ENGINEERING

for

M.Tech. – High Voltage Engineering

(Applicable from 2019-2020 Batches)

UNIVERSITY COLLEGE OF ENGINEERING KAKINADA *(Autonomous)*

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

KAKINADA - 533 003, ANDHRA PRADESH, INDIA

Vision and Mission of the Institute:

Vision:

To be a premier institute of excellence developing highly talented holistic human capital that contributes to the nation through leadership in technology and innovation through engineering education.

Mission:

1. To impart Personnel Skills and Ethical Values for Sustainable Development of the Nation.
2. To create Research & Industry oriented centers of excellence in all engineering disciplines.
3. To be a renowned IPR generator and repository for innovative technologies.
4. To develop Research and Industry oriented technical talent.
5. To benchmark globally the academic & research output.

Vision and Mission of the Department:

Vision:

To be in the forefront in advanced research in emerging areas of Electrical & Electronics Engineering, be proactive with industry in technology development and mould the department into a centre of academic excellence.

Mission:

1. To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.
2. To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.
3. To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.

Programme Education Objectives (PEOs):

PEO1:	To enable the students to learn primarily the concepts of high voltage engineering, working principles, planning, operation, testing and maintenance of the high voltage equipment and systems.
PEO2:	To undertake research in high voltage engineering with emphasis on power systems to strengthen the abilities of the students for employability, to pursue higher learning and to become leaders of academia.
PEO3:	To inculcate leadership and entrepreneurial skills in students to work in a collaborative and interdisciplinary environment.
PEO4:	To make students socially and ethically responsible citizens and to promote life-long learning.

Mapping of Mission statements to PEOs:

Mission of the Department	Programme Education Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.				
To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.				
To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.				

Rubrics:

L-Low**, M-**Medium**, H-**High

Programme Outcomes (POs): HVE

PO1:	The graduate will be able to acquire in depth knowledge in the area of high voltage engineering with emphasis on power system.
PO2:	The graduate will attain the lateral thinking and problem solving capabilities in the area of high voltage engineering with emphasis on power system.
PO3:	The graduate will obtain the capabilities of critical thinking, analyzing real world problems and handling the complexities to arrive feasible and optimal solutions considering societal and environmental factors.
PO4:	The graduate will be able to extract information through literature survey and apply appropriate research methodologies, techniques and tools to solve problems in high voltage engineering with emphasis on power system.
PO5:	The graduate will be able to use the state-of-the-art tools for modelling, simulation and analysis of problems related to high voltage engineering.
PO6:	The graduate will be trained to assess socia l, health, safety, legal, cultural issues and She/he will also be trained on the consequent responsibilities relevant to the professional engineering practices.
PO7:	To sensitize the graduate about the impact of professional engineering solutions in social and environmental contents and demonstrates the knowledge of, and need for sustainable developments.
PO8:	The graduate will become socially responsible and follow ethical practices to contribute to the community for sustainable development of society.
PO9:	The graduate will be able to independently observe and examine critically the outcomes of his actions and reflect on to make corrective measures subsequently and move forward positively by learning through mistakes.
PO10:	The graduate will be able to communicate confidently, make effective presentations and write good reports to engineering community and society.
PO11:	The graduate will demonstrate knowledge and understanding of high voltage engineering with emphasis on power system and management principles and apply the same for efficiently carrying out projects with due consideration to economical and financial factors.
PO12:	The graduate will recognize the need for life-long learning and have the ability to do it independently.

Programme Specific Outcomes (PSOs):

PSO1:	Able to apply the knowledge during the course of the program from basic computing and social science in general and all electrical courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.
PSO2:	Development of environment-conscious, new technologies to enhance the quality of human life.

Mapping of POs, PSOs to PEOs

Programme Outcomes (PO's)	**Programme Education Objectives (PEOs)**			
	PEO1	**PEO2**	**PEO3**	**PEO4**
PO1				
PO2				
PO3				
PO4				
PO5				
PO6				
PO7				
PO8				
PO9				
PO10				
PO11				
PO12				

Programme Specific Outcomes (PSOs)	**Programme Education Objectives (PEOs)**			
	PEO1	**PEO2**	**PEO3**	**PEO4**
PSO1				
PSO2				

Rubrics:

L-Low**, M-**Medium**, H-**High

COURSE STRUCTURE

I Semester

S.No	Course No	Course Name	P. Os	Category	L	T	P	Credits	Marks
1	PC	Generation and Measurement of High Voltages			3	0	0	3	100
2	PC	Dielectrics and Insulation Engineering			3	0	0	3	100
3	PE	Program Elective – I i. Artificial Intelligence Techniques ii. HVDC Transmission iii. Breakdown Phenomenon in Electrical Insulation			3	0	0	3	100
4	PE	Program Elective – II i. High Voltage Power Apparatus and Diagnostics ii. Collision Phenomena in Plasma Science iii. Advanced Electro Magnetic Fields			3	0	0	3	100
5		Research Methodology and IPR			2	0	0	2	100
6		Simulation Laboratory – I			0	0	4	2	100
7		High Voltage Laboratory			0	0	4	2	100
8		Audit Course – I			2	0	0	0	100
				Total	16	0	8	18	

II Semester

S.No	Course No	Course Name	P. Os	Category	L	T	P	Credits	Marks
1	PC	High Voltage Testing Techniques			3	0	0	3	100
2	PC	Surge Phenomenon & Insulation Coordination			3	0	0	3	100
3	PE	Program Elective – III i. Partial Discharge in HV Equipment ii. Gas Insulated Systems and Substations iii. Pulse Power Engineering			3	0	0	3	100
4	PE	Program Elective – IV i. Flexible AC Transmission Systems ii. EHVAC Transmission iii. Smart Grid Technologies			3	0	0	3	100
5		Simulation Laboratory – II			0	0	4	2	100
6		Power Systems Laboratory			0	0	4	2	100
7		Mini Project with Seminar			0	0	4	2	100
8		Audit Course – II			2	0	0	0	100
				Total	14	0	12	18	800

III Semester*

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PE	Program Elective – V i. Reactive Power Compensation & Management. ii. Hybrid electric Vehicles. iii. Energy Auditing, Conservation and Management. iv. Swayam Courses			3	0	0	3	100
2	OE	Open Elective** i. Renewable Energy Technologies. ii. Smart Grid Technologies. iii. Swayam Courses			3	0	0	3	100
3		Dissertation Phase - I / Industrial Project **(to be continued and evaluated next semester)**			0	0	20	10	---
				Total	6	0	20	16	200

* Students can complete these courses through MOOCs (Swayam).

* Chairman in consultation with the local BoS members will float the list of allowed MOOC electives, each academic year.

* The student shall be encouraged to conduct the project in the industry.

** Open Elective subjects are offered to other branches by EEE Department (except for EEE Branch).

IV Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1		Project/ Dissertation Phase-II **(continued from III semester)**			0	0	32	16	100
				Total	0	0	32	16	200

I-M.Tech. I-Semester

COURSE CODE –	GENERATION & MEASUREMENT OF HIGH VOLTAGES	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of Electrical circuits, Electronics and measurements for testing purpose.

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

		Knowledge Level (K)#
CO1	Understand numerical computation of electrostatic problems.	
CO2	Understand the techniques of generation of high AC, DC and transient voltages.	
CO3	Measure high AC, DC and transient voltages.	
CO4	Measure high AC, DC and transient currents.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Electrostatic fields and field stress control** : Electric fields in homogeneous Isotropic materials and in multi dielectric media-Simple configurations-field stress control. Methods of computing electrostatic fields-conductive analogues-Impedance networks Numerical techniques-finite difference method-finite element method and charge simulation method.	
UNIT – 2	**Generation of High AC & DC Voltages**: Direct Voltages : AC to DC conversion methods electrostatic generators-Cascaded Voltage Multipliers. Alternating Voltages : Testing transformers-Resonant circuits and their applications, Tesla coil.	
UNIT – 3	**Generation of Impulse Voltages** : Impulse voltage specifications-Impulse generations circuits-Operation, construction and design of Impulse generators-Generation of switching and long duration impulses. Impulse Currents : Generation of High impulse currents and high current pulses.	
UNIT – 4	**Measurement of High AC & DC Voltages :** Measurement of High D.C. Voltages : Series resistance meters, voltage dividers and generating voltmeters.	

	Measurement of High A.C. Voltages : Series impedance meters electrostatic voltmeters potential transformers and CVTS-voltage dividers and their applications.	
UNIT – 5	**Measurement of Peak Voltages :** Sphere gaps, uniform field gaps, rod gaps.Chubb-Fortesque methods. Passive and active rectifier circuits for voltage dividers. Measurement of Impulse Voltages : Voltage dividers and impulse measuring systems-generalized voltage measuring circuits-transfer characteristics of measuring circuits-L.V. Arms for voltage dividers-compensated dividers. Measurement of Impulse Currents : Resistive shunts-current transformers-Hall Generators and Faraday generators and their applications-Impulse Oscilloscopes.	
	Total	**48 Hrs**

Text Books:

1. High Voltage Engineering – by E.Kuffel and W.S.Zaengl. Pergaman press Oxford, 1984.
2. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Mc.Graw-Hill Books Co., New Delhi, 2nd edition, 1995.

Reference Books:

1. High Voltage Technology – LL Alston, Oxford University Press 1968.
2. High Voltage Measuring Techniques – A. Schwab MIT Press, Cambridge,USA, 1972.
3. Relevant I.S. and IEC Specifications.

I-M.Tech. I-Semester

COURSE CODE –	DIELECTRICS AND INSULATION ENGINEERING	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Concepts of High voltage engineering and basic physics.

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

		Knowledge Level (K)#
CO1	Distinguish between dielectrics and insulating materials.	
CO2	Understand the Properties of insulating materials.	
CO3	Analyze Electrical breakdown in gas and vacuum insulation.	
CO4	Analyze Electrical breakdown in liquid and solid insulation.	
CO5	Understand the insulation design in electrical power apparatus.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**Dielectrics and Insulating Materials**: Review of Dielectric Phenomenon: Complex permittivity – Polarization - Relaxation and resonant models. Solid, Liquid and Gaseous insulating materials-Physical, Thermal & Electrical properties-Classification of Insulating Materials.	
UNIT – 2	**Solid Insulating Materials:** Organic Fiber materials Ceramics & Synthetic polymers and their applications. Liquid Insulating Materials: Insulating oils, their properties and applications. Gaseous Insulating Materials: Air and SF_6- applications in electrical apparatus.	
UNIT – 3	**Breakdown phenomenon in gaseous and vacuum insulation:** Insulation and decay processes-transition from self-sustained discharges to breakdown-Townsend and streamer discharge Panchen's law, Penning effect-Time lags-Surge breakdown voltage-Breakdown and non uniform	

	fields-Vacuum insulation and vacuum breakdown.	
UNIT – 4	**Breakdown Phenomenon in Liquid and Solid Insulation:** pure and commercial liquids-suspended particle and bubble theories-stressed oil volume theory-Breakdown in solid insulation Intrinsic breakdown-Treeing and tracking phenomenon-Thermal breakdown—Breakdown in composite dielectrics.	
UNIT – 5	Insulation design for power cables, capacitors, bushings, switchgear, transformers and rotating machines-resents trends.	
	Total	**48 Hrs**

Text Books:

1. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata McGraw-Hill Books Co., New Delhi, 2^{nd} edition, 1995.
2. Insulating Materials-by Dekker,S.Chanda& Co

Reference Books:

1. High Voltage Engineering – by E.Kuffel and W.S. ZaegnlPergamon press, Oxford, 1984.
2. Electrical Engineering Materials – B. Tareev, M.I.R. Publications, MOSCOW.
3. Physics of Dielectrics - B. Tareev, M.I.R. Publications, MOSCOW
4. High Voltage Technology - LL Alston, Oxford University Press 1968.
5. Insulation Engineering- by Arora ,John Wiley & Sons
6. Dieletrics and waves-by vonhipple,John Wiley & Sons

I-M.Tech. I-Semester

COURSE CODE –	ARTIFICIAL INTELLIGENT TECHNIQUES (ELECTIVE–I)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Differentiate between Algorithmic based methods and knowledge based methods.	
CO2	Use the soft computing techniques for power system problems.	
CO3	Use appropriate AI framework for solving power system problems.	
CO4	Apply GA to power system optimization problems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction** Artificial Neural Networks (ANN) – definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function.	
UNIT– 2	**ANN Paradigms** ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen's self organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.	
UNIT– 3	**Classical and Fuzzy Sets** Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions.	
UNIT– 4	**FUZZY LOGIC CONTROLLER (FLC)** Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets- Defuzzification methods.	
UNIT– 5	**Application of AI Techniques** Speed control of DC motors using fuzzy logic –load flow studies using back propagation algorithm, single area and two area load frequency control using fuzzy logic.	

		Total	**48 Hrs**

Text Books:

1. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by RajasekharanandPai – PHI Publication.
2. Modern power Electronics and AC Drives – B.K.Bose -Prentice Hall, 2002
3. Genetic Algorithms- David E Goldberg. Pearson publications.
5. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH
6. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

I-M.Tech. I-Semester

COURSE CODE –	HVDC TRANSMISSION (ELECTIVE–II)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Knowledge on Power Electronics, Power Systems and High Voltage Engineering.

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

		Knowledge Level (K)#
CO1	Understand the various schemes of HVDC transmission.	
CO2	Understand the basic HVDC transmission equipment.	
CO3	Understand the control of HVDC systems.	
CO4	Understand the interaction between HVAC and HVDC system.	
CO5	Understand the various protection schemes of HVDC engineering.	
CO6	Understand the various schemes of HVDC transmission.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Limitation of EHV AC Transmission, Advantages of HVDC Technical economical reliability aspects. HVDC Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links-Apparatus and its purpose	
UNIT – 2	Static Power Converters: 6-pulse bridge circuit and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Comparison of the performance of diametrical connection with 6-pulse bridge circuit	
UNIT – 3	Control of HVDC Converters and systems : constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, DC power flow control. Factors responsible for generation of Harmonics voltage and current harmonics effect of variation of α and μ. Filters Harmonic elimination.	
UNIT – 4	Interaction between HV AC and DC systems – Voltage interaction, Harmonic instability problems and DC power modulation. Development of DC circuit Breakers, Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.	

UNIT – 5	Transient over voltages in HV DC systems : Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults. Converter faults and protection in HVDC Systems: Converter faults, over current protection - valve group, and DC line protection, circuit breakers. Over voltage protection of converters, surge arresters.	
	Total	**48 Hrs**

Text Books:

1. S Kamakshaih and V Kamaraju:HVDC Transmission- MG hill.
2. K.R.Padiyar : High Voltage Direct current Transmission, Wiley Eastern Ltd., New Delhi – 1992.

Reference Books:

1. E.W. Kimbark : Direct current Transmission, Wiley Inter Science – New York.
2. J.Arillaga : H.V.D.C.Transmission Peter Peregrinus ltd., London UK 1983
3. Vijay K Sood: HVDC and FACTS controllers:Applications of static converters in power systems by, Kluwer Academic Press.

I-M.Tech. I-Semester

COURSE CODE –	BREAKDOWN PHENOMENON IN ELECTRICAL INSULATION (ELECTIVE-I)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Basic physics, conduction phenomena in dielectrics.

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

		Knowledge Level (K)#
CO1	Understand the fundamental process of conduction in gases.	
CO2	Understand ionization and breakdown phenomena in gases.	
CO3	Understand breakdown phenomena in liquid and solid dielectrics.	
CO4	Understand breakdown phenomena in vaccum.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Fundamentals of Electrical Breakdown Phenomena in Gases:** Review of gas laws-mean free path of a particle-velocity distribution of swarm of molecules-Expression for mean free path (λ)-Distribution of free paths-Bohr's model of an atom .calculation of radius of Bohr's orbit Energy of an electron-Ionization energy of an atom calculation of frequency of emitted radiation.	
UNIT – 2	**Ionization in Gases:** Methods of ionization in gases-Ionization by collision-types of inelastic collisions – collision cross sections. Behavior of charged particles in a gas in electric fields of low (E/P)-drift velocity –mobility conditions for low (E/P). **Electrical Breakdown in Uniform Fields:** Voltage-current relationship is gaseous gap (small gaps)-condition for high (E/P)-Townsend's first Ionization coefficient (α) - (α/p) is a function of (E/P)-Experimental determination of (α) –Penning effect	
UNIT – 3	**Self-sustained discharge:** β-process and its limitations cathode process –methods of liberating secondary electrons –Townsend's second ionization coefficient -γ -process . Condition for electric spark breakdown. Secondary emission by gas produced photons – Meta stables-Role of solid contaminants. Electron Attachment, electronegative gases (SF_6etc). Measurement of 'γ'- Paschen's law –expression for Minimum Breakdown	

	voltage and minimum (Pd_{min}) - limitations of Paschen's law. **Breakdown of long gaps: Streamer** Mechanism- Explanation for positive streamer. Estimation of space charge fields (Es) - Anode directed streamer - comparison between Townsend and streamer mechanism. Breakdown in non-uniform fields –corona discharges - difference between DC and AC corona. Effect of polarity on break down of point-plane gaps.	
UNIT – 4	**Breakdown in Solids and Liquid Insulations:** Types of Breakdown: Intrinsic Breakdown – Electronic Breakdown – Streamer Breakdown – Electromechanical Breakdown –Thermal Breakdown -treeing and tracking. Electro – Chemical Breakdown – BD due to thermal discharges. **Breakdown in liquids dielectrics**: Pure and commercial liquids – Breakdown tests – Pre-breakdown currents and breakdown in pure liquids – breakdown in commercial liquids – Suspended particle theory, cavitation and bubble mechanism. Thermal breakdown – Stressed oil – Volume Theory.	
UNIT – 5	**Breakdown in Vacuum Insulation:** Pre-Breakdown currents – Steady currents –Micro discharges-Factors affecting the Breakdown like electrode separation - electrode conditioning - electrode material –Surface condition surface contamination - electrode area and configurations –effect of electrode temperature –frequency of applied voltage – pressure - recovery strength of vacuum gap. Practical Exchange theory –electron beam Hypothesis – Clump mechanism- transition in breakdown mechanisms – criteria for B.D - effect of solids dielectrics in vacuum and liquids.	
	Total	**48 Hrs**

Text Books:

1. Fundamentals of gaseous ionization and plasma electronics by EssamNassar,John Wiley, New York (1974).

References Books:

1. High voltage & electrical insulation by RavindraArora , John willy and sons.
2. High voltage technology –L.L.Alston -Oxford Press (1968).
3. High voltage Engineering Fundamentals E. Kuffel, W. S. Zaengl,andJ. Kuffel oxford (2002).
4. High voltage Engineering, M.S.Naidu and V.Kamaraju (5th edition) McGraw Hill Publishing Co., New Delhi (2011).

I-M.Tech. I-Semester

COURSE CODE –	HIGH VOLTAGE POWER APPARATUS AND DIAGNOSTICS (ELECTIVE-II)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: To know about power transformers, Degree of polymerization, dissolved gas analysis, Fourier Transformer and frequency response analysis of transformers.

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

		Knowledge Level (K)#
CO1	Learn power transformer, types of insulation material.	
CO2	Measurement of tan delta and capacitance of transformer oil.	
CO3	Know the concept of moisture in transformer oil and paper and partial discharges.	
CO4	Know degree of polymerization.	
CO5	Know concept of Fourier Transformer and frequency response analysis of transformer winding.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Introduction to power transformer, important components of power transformer, winding configuration, various types of insulation material, cooling of winding. Reasons of failure of transformer, overvoltage due to switching operation, over-voltage due to lightning impulse, over voltage due to fault, high level of partial discharges, over fluxing.	
UNIT – 2	Tan delta, capacitance in transformer winding, method of measurement of tan delta and capacitance in transformer ,Tan delta ,resistivity and capacitance of transformer oil, bushing capacitance ,tan delta and resistivity, on-site measurement, analysis to detect ageing and likely failure	
UNIT – 3	Moisture in transformer oil and paper, ageing effect of paper, insulation resistance, Method of measurement of polarization, polarization value, method of moisture reduction, winding resistance, Influence with regard to life of transformer. Partial Discharges in transformer, causes of partial discharges, concept of partial discharges, acoustic method of measurement of partial discharges, discharges in oil, discharges in paper, method of reduction of partial discharges, analysis and detection of partial discharge sites within transformer volume.	

UNIT – 4	Degree of polymerization (DP) of transformer paper, effect of DP on life of transformer, effect of transformer temperature on degree of polymerization, furfural content in oil insulation, inter – relationship between degree of polymerization and furfural content, reduction of degree of polymerization in transformer paper. Dissolved gas analysis in transformer oil, various gas product in transformer oil, tolerable level of gases in transformer onload , detection of important gases in transformer, causes of various gases, likely reason of gases with reference to high temperature and partial discharges.	
UNIT – 5	Fourier Transform and frequency response analysis of transformer winding, concept of Fourier Transformer with regard to configuration of winding, comparison of frequency response of LV , HV and tapping winding, concept of winding movement on the basis of frequency comparison, turn failure.	
	Total	**48 Hrs**

Text Book:

1. Transformer, Bharat Heavy Electricals Limited (Bhopal), Second edition 2003,First Edition 1987 Tata Mc.Graw-hill Publishing Company Ltd. Mc.Graw –Hill officePage 1- 602

Reference book

1 Seminar on fault finding and life assessment of power transformers Proceedings 25-26 April2008 New Delhi, Organized by Central Board of Irrigation and Power, New Delhi in association with Omicron India.

2.Transformer Engineering, Blue mend boission, Wiley international publication

I-M.Tech. I-Semester

COURSE CODE –	COLLISION PHENOMENA IN PLASMA SCIENCE (ELECTIVE-II)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Introduction to plasma physics and quantum physics

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

		Knowledge Level (K)#
CO1	Analyze the collision phenomena in different materials.	
CO2	Calculate the forces between ions and molecules.	
CO3	Evaluate the ‘α’	
CO4	Analyze transition from Streamer to Townsend mechanisms of breakdown.	
CO5	Electric glow discharge and plasma glow discharge.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Ionization, Deionization and Electron Emission :Ionization and plasma conductivity, Production of charged particles, Ionization by cosmic rays, Thermal ionization. The free path, excited states, metastable states. Diffusion, Recombination, Negative ions. Photoelectric emission, Thermionic emission, Field emission.	
UNIT – 2	Behavior of charged particles in a gas in electric fields of low E/P and high E/P, Definition and significance of mobility, Forces between ions and molecules, Diffusion under low fields, Electron drift velocity.	
UNIT – 3	What is high E/P? Coefficient of ionization by electron collision, evaluation of $\propto$, electron avalanche, effect of the cathode, Ionization coefficient in alternating fields. The Self-Sustaining Discharge Breakdown Mechanisms: Ionization by positive-ion collision, Cathode processes, space-charge field of an avalanche. Critical avalanche size,	
UNIT – 4	Townsend mechanism and its limitations, Streamer formation. The transition between the breakdown mechanisms, The effect of electron attachment. Partial Breakdown and Breakdown Under Alternating Fields: Electron current, positive-ion current, total current, characteristic time, effect of space charge, Anode coronas, Cathode coronas.	
UNIT – 5	The Glow and Plasma: General description, The cathode zone, Negative	

	glow and Faraday dark space, positive column, Anode region, other effects. Definition of plasma, Debye length, scope of known plasmas, Plasma oscillations, high-temperature plasmas, Plasma diagnostics	
	Total	**48 Hrs**

Text Book:

1. Fundamentals of Gaseous Ionization And Plasma Electronics by Essam Nasser, John Willey & Sons, Printed in America, 1971.

I-M.Tech. I-Semester

COURSE CODE –	ADVANCED ELECTRO MAGNETIC FIELDS (ELECTIVE-II)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: To know the elements of Electromagnetic and electro static field theory along with the behavior of conductors in an electric field.

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

		Knowledge Level (K)#
CO1	Know about analysis of electrostatic fields and properties of potential gradients.	
CO2	Know about the dielectric boundary conditions and electric stress control and optimization and time varying fields.	
CO3	Understand different Electric Fields.	
CO4	Distinguish between conductors and dielectrics.	
CO5	Understand the force in magnetic fields and time varying fields.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Electrostatics:** Electrostatic Fields – Coulomb's Law – Electric Field Intensity (EFI) – EFI due to a line and a surface charge – Work done in moving a point charge in an electrostatic field – Electric Potential – Properties of potential function – Potential gradient – Gauss's law – Application of Gauss's Law – Maxwell's first law, div (D)=ρv – Laplace's and Poisson's equations – Solution of Laplace's equation in one variable	
UNIT – 2	**Electric fields-1** Introduction, Analytical calculation of space-charge-free fields, simple geometries, transmission conductors to ground, fields in multi dielectric media, experimental analogs for space-space-charge-free fields, electrolytic tank, semi conducting paper analog, resistive-mesh analog.,	
UNIT – 3	**Electric fields-2** Analytical Calculations of Fields With Space Charges, Numerical Computation of Fields With Space Charges, Finite Element Technique, Finite Element Technique Combined With The Method Of Characteristics, Charge-Simulation Technique Combined With The Method Of Residues,	

	Electric Stress Control And Optimization, Electric Stress Control, Electric Stress Optimization	
UNIT – 4	**Conductors & Dielectrics:** Behavior of conductors in an electric field – Conductors and Insulators – Electric field inside a dielectric material – polarization – Dielectric – Conductor and Dielectric – Dielectric boundary conditions – Energy stored and energy density in a static electric field – Current density – conduction and Convection current densities – Ohm's law in point form – Equation of continuity	
UNIT – 5	**Force in Magnetic fields &Time Varying Fields:** Magnetic force - Moving charges in a Magnetic field – Lorentz force equation — a differential current loop as a magnetic dipole ,Time varying fields – Faraday's laws of electromagnetic induction – Its integral and point forms ,Statically and Dynamically induced EMFs -Modification of Maxwell's equations for time varying fields – Displacement current	
	Total	**48 Hrs**

Text Books:

1. "Engineering Electromagnetic" by William H. Hayt& John. A. Buck McGraw-Hill Companies, 7th Editon.2005.
2. "Electromagnetics" by J. D Kraus Mc.Graw-Hill Inc. 4th edition 1992.

Reference Books:

1. Field Theory ", Gangadhar, Khanna Publishers.
2. Elements of Electromagnetic field theory ", Sadiku, Oxford Publ.
3. "Electromagnetics" by J P Tewari.
4. "Introduction to E-Magnetics" by CR Paul and S.A. Nasar, McGraw-Hill Publications
5. "Introduction to Electro Dynamics" by D J Griffiths, Prentice-Hall of India Pvt.Ltd, 2nd edition
6. "Electromagnetics" by Plonsy and Collin
7. "Engineering Electro magnetics" by Nathan Ida, Springer (India) Pvt. Ltd.2nd Edition.

I-M.Tech. I-Semester

COURSE CODE –	RESEARCH METHODOLOGY AND IPR	CATEGORY	L-T-P	CREDITS 2

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

I-M.Tech. I-Semester

COURSE CODE –	SIMULATION LABORATORY – I	CATEGORY	L-T-P 0-0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Distinguish between different load flow methods.	
CO2	Analyze Y-bus & Z-bus algorithm.	
CO3	Analyze symmetrical & unsymmetrical faults.	
CO4	Understand importance of Load flow control	
CO5	Understand importance of Economic load dispatch and transient stability analysis.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

S.No.	CONTENTS
1	Formation of Y- Bus by Direct-Inspection Method.
2	Load Flow Solution Using Gauss Siedel Method
3	Load Flow Solution Using Newton Raphson Method
4	Load Flow Solution Using Fast Decoupled Method
5	Formation of Z-Bus by Z-bus building algorithm
6	Symmetrical Fault analysis using Z-bus
7	Unsymmetrical Fault analysis using Z-bus
8	Economic Load Dispatch with & without transmission losses
9	Transient Stability Analysis Using Point By Point Method
10	Load Frequency Control of Single Area Control & Two Area Control system with and without controllers.

I-M.Tech. I-Semester

COURSE CODE –	HIGH VOLTAGE LABORATORY	CATEGORY	L-T-P 0-0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Design the various testing procedures of various insulators.	
CO2	Design the procedure for calibration of tong tester.	
CO3	Compute the breakdown strength of dielectric coil.	
CO4	Determine he leakage current of various insulators.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	List of Experiments
1	Millivolt drop test and Tong tester calibration
2	Breakdown characteristics of sphere-sphere gap
3	Measurement of Leakage current and breakdown voltage of pin insulator
4	Breakdown test of transformer oil
5	Breakdown characteristics of rod-rod gap
6	Measurement of Leakage current and insulation resistance of polypropylene scale
7	Measurement of Leakage current and insulation resistance of polypropylene rope
8	Breakdown characteristics of plane-rod-gap
9	Measurement of leakage current and breakdown voltage of suspension insulator
10	Breakdown characteristics of point-sphere gap
11	Measurement of tan delta and dielectric constant
12	Power frequency testing of HV transformer
13	Power frequency testing of HV Bushing
14	Power frequency testing of HV Cable.

I-M.Tech. I-Semester

COURSE CODE –	AUDIT COURSE – I	CATEGORY	L-T-P 2-0-0	CREDITS 0

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

I-M.Tech. II-Semester

COURSE CODE –	HIGH VOLTAGE TESTING TECHNIQUES	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of high voltage engineering.

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

		Knowledge Level (K)#
CO1	Understand non-destructive testing techniques	
CO2	Analyse HV testing of apparatus	
CO3	Understand HVAC testing methods.	
CO4	Analyse impulse testing electrical equipment's.	
CO5	Learn partial discharge measurement techniques.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Non Destructive Testing Techniques : Measurement of DC Resistivity – Dielectric loss and dielectric constant of insulating materials – Schering bridge method – Transformer ratio arm bridge for high voltage and high current applications – null detectors.	
UNIT – 2	High Voltage Testing of Power Apparatus: Need for testing standards – Standards for porcelain/Glass insulators-Classification of porcelain/glass insulator tests – Tests for cap and pin porcelain/Glass insulators.	
UNIT – 3	High voltage AC testing methods-Power frequency tests-Over voltage tests on insulators, Isolators, Circuit Breakers and power cables. Artificial Contamination Tests : Contamination flashover phenomena-Contamination Severity-Artificial contamination tests-Laboratory Testing versus in-Service Performance-Case study.	
UNIT – 4	Impulse Testing: Impulse testing of transformers, insulators, Surge diverters, Bushings, cables, circuit breakers.	
UNIT – 5	Partial Discharge Measurement: PD equivalent model-PD currents-PD measuring circuits-Straight and balanced detectors-Location and estimation of PD in power apparatus-PD measurement by non-electrical methods-Calibration of PD detectors. RIV Measurements : Radio Interference – RIV – Measurement of RI and RIV in laboratories and in field. Different test arrangements and their limitations.	
	Total	**48 Hrs**

Text Books:

1. High Voltage Engineering – by E.KUFFEL and W.S.ZAENGL, Pergamon press, Oxford 1984.
2. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata McGraw Hill Publishing Company Limited, New Delhi – 2001.

Reference Books:

1. Discharge Detection in H.V. Equipment – by KREUGER, F.H. Haywood London – 1964.
2. Hyltencavallius. N. High voltage laboratory planning EnileHaefely&Co. Ltd. Based Switzerland 1988.
3. Ryan H.M. and Whiskand: design and operation perspective of British UHV Lab IEE pre 133 H.V. Testing Techniques Halfly

I-M.Tech. II-Semester

COURSE CODE –	SURGE PHENOMENON AND INSULATION COORDINATION	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Basic concepts of travelling wave techniques and their applications in electrical power systems, lightening and switching over voltages, insulation co-ordination in power systems.

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

		Knowledge Level (K)#
CO1	Understand concepts of travelling waves and their behavior in transmission systems.	
CO2	Understand lighting phenomena and over voltages in power systems.	
CO3	Understand the behavior of the transformer due to surge voltages induced in the windings.	
CO4	Understand insulation coordination in a substation.	
CO5	Understand operations of over voltage protective devices.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Traveling Waves: Transmission line equation, attenuation and distortion point-Typical cases. Reflection of traveling waves: Behaviors of waves at a transaction point-Typical case. Travelling waves on multi conductor systems	
UNIT – 2	Successive Reflections: Reflection lattice, Effect of insulation capacitance. Standing waves and natural frequencies of transmission lines-Transient response of lines and systems with distributed parameters	
UNIT – 3	Lightning Phenomena and over voltage in power systems. Mechanism of the lightning stroke – Mathematical model of the lightning stroke. Over voltages produced in power systems due to lightning – Over voltage due to faults in the system and switching surges. General principles of lightning protection – Tower – Footing resistance – Insulation withstand voltages and impulse flashover characteristics of protective gaps.	
UNIT – 4	Surge Voltage distribution in transformer windings initial and final distribution characteristics: Protection of windings against over voltages. Protection of transmission lines, transformers and rotating machines against over voltages. Use of rod gaps and lightning arresters protective characteristics. Selection of the lightning arresters.	
UNIT – 5	Insulation coordination lightning surge and switching surge characteristics	

	of insulation structures. Geo-metric gap factors test procedures, correlation between insulation for protective levels. Protective devices Zno arresters, valve type-etc., protective tubes	
	Total	**48 Hrs**

Text Books:

1. Traveling waves of Transmission systems – by LV Bewley. Dover publications Inc., New York (1963).

Reference Books:

1. Lewis, w.w., protection of transmission lines and systems against lightining, dover publications, Inc., New York (1965).
2. Diesendorf.W, Insulation Co-ordination ELBS in H.V. Electrical Power Systems , Butter worth publications, London, (1974).
3. Rakesh Das Begmudre,E.H.V. Transmission Engineering: Wielly Eastern Ltd., New Delhi, (1986).

I-M.Tech. II-Semester

COURSE CODE –	PARTIAL DISCHARGE IN HV EQUIPMENT (ELECTIVE-III)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Knowledge in High Voltage Equipment.

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

		Knowledge Level (K)#
CO1	Analyze the types of partial discharge that occurs in the insulation systems and in apparatus.	
CO2	Compute the partial discharges in solid dielectrics.	
CO3	Analyze the detection of discharges using different detection circuits.	
CO4	Location of partial discharge in electrical apparatus and systems.	
CO5	Detection of partial discharges in various instruments.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Types of partial discharges and its occurrence and recurrence and magnitudes: Definition of Partial discharges, inception of internal discharges, Inception of corona discharges.	
UNIT – 2	Discharges by electrical treeing. Discharges at AC Voltages, corona discharges, Discharges at D.C. Voltages, discharges at impulse voltages. Object of discharge detection, Quantities related to the magnitude of discharges, choice of PD as a measure for discharges.	
UNIT – 3	Electrical discharge detection & Detection circuits : Basic diagram, amplification of impulses, sensitivity, resolution, observation. Straight detection. Balanced detection, calibrators, Interferences, choice between straight detection & balance detection, common mode rejection.	
UNIT – 4	Location of Partial discharges: Non-electric location, location by separation of electrodes, location with electrical probes. Location by traveling waves, PD location in cables & switchgear by traveling waves. Evaluation of discharges: Recognition, mechanisms of deterioration, evaluation, specification.	
UNIT – 5	Detection in actual specimen: Detection in capacitors, cables, bushings. Transformers, machine insulation, Gas-insulated switchgear.	
	Total	**48 Hrs**

Text Books:

1. Partial Discharges in HV Equipment by F.Kruguer, Butterworths& Co., Publications Ltd., 1989.
2. Partial Discharges in Electrical Power Apparatus. by Dieter Konig, Y. NarayanaRao- VDE-Verlag publisher

I-M.Tech. II-Semester

COURSE CODE –	GAS INSULATED SYSTEMS AND SUBSTATIONS (ELECTIVE-III)	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Conduction and Breakdown in gases, and substation.

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

		Knowledge Level (K)#
CO1	Know the Properties of SF_6	
CO2	Understand design and construction of G.I.S Substations	
CO3	Analyze transient Phenomenon and testing of G.I.S	
CO4	Analyze diagnostics of GIS	
CO5	Understand layout of GIS	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**Introduction to GIS and Properties of SF6:** Characteristics of GIS, Introduction to SF_6, Physical Properties, Chemical Properties, Electrical Properties, Specifications of SF_6 Gas for GIS Applications, Handling of SF_6 Gas Before Use, Safe Handling of SF_6 Gas in Electrical Equipment, Equipment for Handling the SF_6 Gas, SF_6 and Environment.	
UNIT – 2	**Layout of GIS Stations:** Advantages of GIS Stations, Comparison With Air Insulated Substations, Economics of GIS,User Requirements for GIS,Main Features of a GIS,General Arrangement of a GIS,Planning and Installation,Components of a GIS station.	
UNIT – 3	**Design and Construction of GIS Stations:** Introduction,Ratings of GIS Components,DesignFeatures,Estimation of Different types of Electrical Stresses,Design Aspects of GIS 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 in GIS ,GIS Grounding Systems,Gas handling and Monitoring System Design.	
UNIT – 4	**Testing of GIS** Introduction, Various Tests on GIS,Design Approach for Manufacturing	

	and Type Tests,Quality Assurance in Manufacturing,Shipping and Erection,On-Site Testing of GIS, Dielectric Tests, commonly used On-site Test Methods,Experience during On-Site Testing,Condition Monitoring and Diagnostic Methods	
UNIT – 5	**GIS Diagnostics and Fast Transient Phenomena in GIS** Introduction,Characteristics of imperfections inInsulation,Insulation Diagnostic Methods,PDMeasurement,UHFMethod,Disconnector Switching in Relation to Very Fast Transients,Origin of VFTO, Propagation and Mechanism of VFTO,VFTO Characteristics,Effect of VFTO,Testing of GIS for VFTO.	
	Total	**48 Hrs**

Text Book:

1. M.S.Naidu,"Gas Insulated Substations" I.K International publishing house Pvt.Ltd, New Delhi.

Reference Books:

1. O.Kindsen&K.V.Menon, " Future developments trend in GIS Technology" 3rd workshop & conference on EHV Technology, Indian Institute of Science, Bangalore, August 2-4, 1995.
2. V.N.Maller and M.S.Naidu "Advances in High Voltage Insulation & Arc Interruption in SF6 and Vaccum", Pergamon Press, Oxford, 1982.

I-M.Tech. II-Semester

COURSE CODE –	**PULSE POWER ENGINEERING (ELECTIVE-III)**	**CATEGORY**	**L-T-P 3-0-0**	**CREDITS 3**

Pre-requisite: Basic concepts of Pulse forming networks and energy storage devices.

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

		Knowledge Level (K)#
CO1	Compute the static and dynamic breakdown in various dielectrics	
CO2	Various energy storage devices, repetitive generators and cumulative pulse lines.	
CO3	Analyze about various switching operations.	
CO4	Design about various pulse forming networks and their applications.	
CO5	Design the various Pulse power generators.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**Static and Dynamic Breakdown Strength of dielectric Materials** Introduction-Gases-static breakdown-pulsed breakdown-spark formation-liquids-basic electrical Process-steamer breakdown-practical considerations-solids-General observations-charge Transport, injection and Breakdown-statistical Interpretation of breakdown Strength Measurements	
UNIT – 2	**Energy Storage** Pulse Discharge Capacitors-Marx Generators-classical Marx generators-LC Marx Generator-Basic Pulsed-Power Energy Transfer Stage-inductive energy storage-power and voltage multiplication-rotors and homo polar Generators	
UNIT – 3	**Switches** Closing switches-gas switches-semiconductor closing switches-magnetic switches-summary-opening switches-fuses-mechanical interrupters-superconducting opening switches-plasma opening switches-plasma flow switches-semiconductor opening switches	
UNIT – 4	**Pulse forming networks:** Transmission lines-terminations and junctions-transmission lines with losses-the finite transmission line as a circuit element-production of pulses with lossless transmission lines-RLC networks-circuit simulation with	

	LEITER Power and Voltage Adding: Adding of Power-Voltage Adding-voltage adding by transit-time Isolation- voltage adding by Inductive Isolation-Blumlein Generators-Cumulative Pulse Lines	
UNIT – 5	**Examples of Pulsed-power Generators:** Single-pulse generators: KALIF-PBFA 2 and the Z-Machine- HERMES III Repetitive Generators: RHEPP and Generators with opening switches	
	Total	**48 Hrs**

Text Books:

1. Pulsed Power Engineering by Professor Dr.HasjoachimBluhm.

Reference Books:

1. Explosive Pulsed Power -L. L. Altgilbers, J. Baird, B. Freeman, C. S. Lynch, and S. I. Shkuratov -Imperial College Press.
2. Advances in Pulsed Power Technology, Vol. 1 & 2, Plenum Press.
3. Pulsed Power Systems: Principles and Applications-Dr.HasjoachimBluhm-Springer

I-M.Tech. II-Semester

COURSE CODE –	FLEXIBLE AC TRANSMISSION SYSTEMS (ELECTIVE–IV)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Concepts on Power Electronics and Power Systems

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

		Knowledge Level (K)#
CO1	Know the performance improvement of transmission system with FACTS.	
CO2	Get the knowledge of effect of static shunt and series compensation.	
CO3	Know the principle of operation and various controls of UPFC	
CO4	Determine an appropriate FACTS device for different types of applications.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	FACTS concepts, Transmission interconnections, power flow in an AC System, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.	
UNIT – 2	Basic concept of voltage and current source converters, comparison of current source converters with voltage source converters. Static shunt compensation : Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable VAr generation, variable impedance type static VAr generation, switching converter type VAr generation, hybrid VAr generation.	
UNIT – 3	**SVC** and STATCOM: The regulation slope, transfer function and dynamic performance, transient stability enhancement and power oscillation damping, operating point control and summary of compensation control.	
UNIT – 4	Static series compensators: Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.	
UNIT – 5	Unified Power Flow Controller: Basic operating principle, conventional transmission control capabilities, independent real and reactive power flow control, comparison of the UPFC to series compensators and phase angle regulators. Introduction to Inter line Power Flow Controller (IPFC)	
	Total	**48 Hrs**

Text Books:

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press.
   Indian Edition is available:--Standard Publications

Reference Books:

1. Sang.Y.H and John.A.T, "Flexible AC Transmission systems" IEEE Press (2006).
2. HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers

I-M.Tech. II-Semester

COURSE CODE –	EHVAC TRANSMISSION (ELECTIVE–IV)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Transmission line parameters and properties, Corona etc.

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

		Knowledge Level (K)#
CO1	Calculate the transmission line parameters.	
CO2	Calculate the field effects on EHV and UHV AC lines.	
CO3	Determine the corona, RI and audible noise in EHV and UHV lines.	
CO4	Analyze voltage control and compensation problems in EHV and UHV transmission systems.	
CO5	Understand reactive power compensation using SVC and TCR	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	E.H.V. A.C. Transmission, line trends and preliminary aspects ,standard transmission voltages – power handling capacities and line losses – mechanical aspects. Calculation of line resistance and inductance: resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi conductor lines, Maxwell's coefficient matrix. Line capacitance calculation.capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.	
UNIT – 2	Calculation of electro static field of AC lines - Effect of high electrostatic field on biological organisms and human beings. Surface voltage Gradient on conductors, surface gradient on two conductor bundle and cosine law, maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.	
UNIT – 3	Corona : Corona in EHV lines – corona loss formulae – attenuation of traveling waves due to corona – Audio noise due to corona, its generation, characteristics and limits, measurement of audio noise.	
UNIT – 4	Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents,	

	voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines	
UNIT – 5	Reactive power compensating systems : Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics injected into the system.	
	Total	**48 Hrs**

Text Books :

1. Extra High Voltage AC Transmission Engineering – Rakesh Das Begamudre, Wiley Eastern ltd., New Delhi – 1987.
2. EHV Transmission line reference book – Edison Electric Institute (GEC) 1986.

I-M.Tech. II-Semester

COURSE CODE –	SMART GRID TECHNOLOGIES (ELECTIVE–IV)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

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

		Knowledge Level (K)#
CO1	Understand smart grids and analyze the smart grid policies and developments in smart grids.	
CO2	Develop concepts of smart grid technologies in hybrid electrical vehicles etc.	
CO3	Understand smart substations, feeder automation, GIS etc.	
CO4	Analyze micro grids and distributed generation systems.	
CO5	Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
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 on Smart Grid. Case study of Smart Grid.	
UNIT – 2	**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, 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.	
UNIT – 3	**Smart Grid Technologies: 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(PMU).	
UNIT – 4	**Microgrids and Distributed Energy Resources:** Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic	

	solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.	
UNIT – 5	**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. **Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).	
	Total	**48 Hrs**

Text 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

Reference Books:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama,"Smart Grid: Technology and Applications", Wiley
2. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell 19
3. Peter S. Fox Penner, "Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities", Island Press; 1 edition 8 Jun 2010
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 30 Jun 2009
5. Stuart Borlase, "Smart Grids (Power Engineering)", CRC Press
6. Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving Sustainability: 1", Artech House Publishers July 2011

I-M.Tech. II-Semester

COURSE CODE –	SIMULATION LABORATORY – II	CATEGORY	L-T-P 0-0-4	CREDITS 2

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.NO.	CONTENTS
1	Simulation of Marx circuit.
2	Simulation of Tesla coil circuit.
3	Simulation and generation of lightning, switching and pulse current/voltage waveform.
4	Simulation of Impulse current generation circuit.
5	Simulation of Impulse voltage generation circuit.
6	Development of model for PV module and simulation of performance curves and their variation with temperature and irradiation.
7	Development of model for PV array and simulation of performance curves and their variation with temperature and irradiation.
8	Develop a model for a wind turbine generator and simulate performance curves ($C_pV_s\lambda$) and (T_mV_sN).
9	Develop a model for a wind turbine generator, PV array and a PV-Wind hybrid system to analyze the performance of the hybrid system connected to a pump load under various wind and irradiance conditions at geographical location Kakinada. Assume PV array capacity of 480Wp and wind turbine rating of 700 Watts. Assume data not given.
10	Electric Field Analysis of 11kV Polymer Insulator.
11	Electric Field Analysis of Pin Insulator.
12	Electric Field Analysis of Sphere to Sphere gap
13	Electric Field Analysis of Rod to Rod gap.
14	Electric Field Analysis of Point to Sphere gap.
15	Electric Field Analysis of Plane to Rod gap.

I-M.Tech. II-Semester

COURSE CODE –	POWER SYSTEMS LABORATORY	CATEGORY	L-T-P 0 -0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Distinguish between sequence impedances of alternator and transformer.	
CO2	Understand the Ferranti effect.	
CO3	Analyze performance and importance of transmission line parameters.	
CO4	Understand the operation of various protection relays.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.NO.	CONTENTS
1	Determination of Sequence Impendences of an Alternator by direct method.
2	Determination of Sequence impedances of an Alternator by fault Analysis.
3	Measurement of sequence impedance of a three phase transformer a) By application of sequence voltage. b) Using fault analysis.
4	Power angle characteristics of a salient pole Synchronous Machine.
5	Poly-phase connection on three single phase transformers and measurement of phase displacement.
6	Determination of equivalent circuit of 3-winding Transformer.
7	Measurement of ABCD parameters on transmission line model.
8	Performance of long transmission line without compensation.
9	Study of Ferranti effect in long transmission line.
10	Performance of long transmission line with shunt compensation.
11	To study the differential and percentage bias integrated relay operations.
12	Performance characteristics of Over current relay
13	To study the protection of generator and transformer.

I-M.Tech. II-Semester

COURSE CODE –	MINI PROJECT WITH SEMINAR	CATEGORY	L-T-P 0-0-4	CREDITS 2

Mini Project with Seminar

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee.

I-M.Tech. II-Semester

COURSE CODE –	AUDIT COURSE – II	CATEGORY	L-T-P 2-0-0	CREDITS 0

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

II M.Tech I-Semester

COURSE CODE –	REACTIVE POWER COMPENSATION & MANAGEMENT (ELECTIVE-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Learn various load compensations.	
CO2	Obtain the mathematical model of reactive power compensating devices.	
CO3	Get application of reactive power compensation in electrical traction & arc furnaces.	
CO4		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

- **(Please fill the above with Levels of Correlation, viz., L, M, H)**

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Load Compensation:** Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.	
UNIT– 2	**Reactive power compensation in transmission system:** Steady state - Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples Transient state - Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples	
UNIT– 3	**Reactive power coordination:** Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.	
UNIT– 4	**Distribution side Reactive power Management:** System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks. **User side reactive power management:** KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations.	
UNIT– 5	**Reactive power management in electric traction systems and are furnaces:** Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace.	
	Total	**48 Hrs**

Reference Books:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982
2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004

II M.Tech. I-Semester

COURSE CODE –	HYBRID ELECTRIC VEHICLES (ELECTIVE–V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Know the concept of electric vehicles and hybrid electric vehicles.	
CO2	Familiar with different motors used for hybrid electric vehicles.	
CO3	Understand the power converters used in hybrid electric vehicles	
CO4	Know different batteries and other energy storage systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs.	
UNIT– 2	**Hybridization of Automobile:** Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.	
UNIT– 3	**Plug-in Hybrid Electric Vehicle:** PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.	
UNIT– 4	**Power Electronics in HEVs:** Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.	
UNIT– 5	**Battery and Storage Systems** Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource	
	Total	**48 Hrs**

Text Books

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. H. Partab: Modern Electric Traction - DhanpatRai& Co, 2007.

Research Books:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrstructure and the market”, Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995.

II M.Tech I-Semester

COURSE CODE –	ENERGY AUDITING, CONSERVATION AND MANAGEMENT (ELECTIVE-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand the principle of energy audit and their economic aspects.	
CO2	Recommend energy efficient motors and design good lighting system.	
CO3	Understand advantages to improve the power factor.	
CO4	Evaluate the depreciation of equipment.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Basic Principles of Energy Audit** Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams and load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.	
UNIT– 2	**Energy Management** Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manager, qualities and functions, language, Questionnaire – check list for top management	
UNIT– 3	**Energy Efficient Motors and Lighting** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed , variable duty cycle systems, RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice, lighting control, lighting energy audit	
UNIT– 4	**Power Factor Improvement and energy instruments** Power factor – methods of improvement, location of capacitors, Power factor with non-linear loads, effect of harmonics on p.f, p.f motor controllers – Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's	
UNIT– 5	**Economic Aspects and their computation** Economics Analysis depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method, net present value method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.	
	Total	**48 Hrs**

Text Books:

1. Energy management by W.R.Murphy & G.Mckay Butter worth, Heinemann publications, 1982.
2. Energy management hand book by W.CTurner, John wiley and sons, 1982.

Reference Books:

1. Energy efficient electric motors by John.C.Andreas, Marcel Dekker Inc Ltd-2nd edition,1995
2. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

II M.Tech I-Semester

COURSE CODE –	RENEWABLE ENERGY TECHNOLOGIES (Open Elective)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Analyze solar radiation data, extraterrestrial radiation, radiation on earth's surface and solar Energy Storage.	
CO2	Design the of Wind Energy Systems.	
CO3	Design of biomass digesters, Geothermal plants and its working characteristics	
CO4	Know the Energy production from OTEC, Tidal and Waves.	
CO5	Evaluate the concept and working of Fuel cells & MHD power generation.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Solar Energy:** Introduction, Renewable Sources, prospects, Solar radiation at the Earth Surface, Solar Energy Collectors-Flat plate Collectors, concentrating collectors, advantages and dis advantages, Solar Energy storage systems – Solar Pond. Applications of Solar Energy-Solar water heating, Solar Green house.	
UNIT– 2	**Wind Energy:** Introduction, basic Principles of Wind Energy Conversion, the nature of Wind, the power in the wind, Wind Energy Conversion, Site selection considerations, basic components of a WECS(Wind Energy Conversion Systems),Classification of WEC Systems, Advantages and Disadvantages of WECS, Applications of Wind Energy	
UNIT– 3	**Biomass and Geothermal Energy:** Introduction, Biomass conversion technologies, Photosynthesis, factors affecting Bio digestion, classification of biogas plants, advantages and their disadvantages, Types of biogas plants, selection of site for a biogas plant **Geothermal Energy**: Introduction, Geothermal Sources, Applications of geothermal Energy, Advantages and Disadvantages, operational and Environmental problems.	
UNIT– 4	**Energy From oceans, Waves & Tides:** **Oceans:** Introduction, Ocean Thermal Electric Conversion (OTEC), methods, Advantages and Disadvantages, prospects of OTEC in India. **Waves :** Introduction, Energy and Power from the waves, Wave Energy conversion devices, Advantages and Disadvantages **Tides**: Basic principle of Tide Energy, Components of Tidal Energy, Advantages and limitations of Tidal power Generation.	
UNIT– 5	**Chemical Energy Sources:** **Fuel Cells:** Introduction, Fuel Cell Equivalent Circuit, operation of Fuel cell,	

	types of Fuel Cells, Advantages and Disadvantages of Fuel Cells, Applications of Fuel Cells. **Hydrogen Energy**: Introduction, Methods of Hydrogen production, Storage and Applications **Magneto Hydro Dynamic (MHD) Power generation**: Principle of Operation, Types, advantages and disadvantages.	
	Total	**48 Hrs**

Text Books:

1. G.D.Rai, Non-Conventional Energy Sources, khanna Publications, 2011.
2. John Twidell & Tony Weir, Renewable Energy Sources, Taylor & francis, 2013.

Reference Books:

1 .S.P.Sukhatme & J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage,TMH, 2011

2.John Andrews & Nick Jelly, Energy Science- principles, technologies and Impacts,Oxford.

II-M.Tech. I-Semester

COURSE CODE –	**SMART GRID TECHNOLOGIES (OPEN ELECTIVE)**	**CATEGORY**	**L-T-P 3 -0-0**	**CREDITS 3**

Pre-requisite: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

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

		Knowledge Level (K)#
CO1	Understand smart grids and analyze the smart grid policies and developments in smart grids.	
CO2	Develop concepts of smart grid technologies in hybrid electrical vehicles etc.	
CO3	Understand smart substations, feeder automation, GIS etc.	
CO4	Analyze micro grids and distributed generation systems.	
CO5	Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
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 on Smart Grid. Case study of Smart Grid.	
UNIT – 2	**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, 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.	
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UNIT – 4	**Microgrids and Distributed Energy Resources:** Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of	

	interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.	
UNIT – 5	**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. **Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).	
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2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press

Reference Books:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama,"Smart Grid: Technology and Applications", Wiley
2. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell 19
3. Peter S. Fox Penner, "Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities", Island Press; 1 edition 8 Jun 2010
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