ACADEMIC REGULATIONS COURSE STRUCTURE AND DETAILED SYLLABUS

ELECTRICAL AND ELECTRONICS ENGINEERING

for

M.Tech. – High Voltage Engineering

(Applicable from 2023-2024 Batches)

UNIVERSITY COLLEGE OF ENGINEERING KAKINADA *(Autonomous)*

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

KAKINADA - 533 003, ANDHRA PRADESH, INDIA

Dr. N. Sumathi (Member)	Prof. C. C. Reddy (Member)	Dr. A. V. Giridhar (Member)	Dr. Saibal Chatterjee (Member)
	Attended Online	Attended Online	Attended Online
Dr. N. Vasudev (Member)	Dr. Chiranjib Koley (Member)	Dr. K. V. S. Ramachanadra Murthy (Member)	Dr. K. Ravindra (Chairman)
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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 education for meeting the needs of academic, research and industry in the areas of Electrical & Electronics Engineering, and make the department a centre of academic excellence.

Mission:

1. To provide the requisite theoretical and practical knowledge by offering appropriate courses.
2. To promote research oriented innovation culture among the students.
3. To create social awareness and ethical values in the graduates for betterment of the society.
4. To help the students in building professional capabilities in Electrical & Electronics Engineering.

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Program Education Objectives (PEOs):

PEO1:	To enable the students to learn the core concepts of high voltage engineering.
PEO2:	To prepare students in latest technology for carrying out research and development related to high voltage engineering.
PEO3:	To impart knowledge to the students in high voltage engineering for enabling to work ethically in industries and for the benefit of society.

Mapping of Mission statements to PEOs:

	PEO1	PEO2	PEO3
M1	2	1	3
M2	2	3	2
M3	2	1	3
M4	2	2	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

Program Outcomes (POs): HVE

PO1:	An ability to independently carry out research /investigation and development work to solve practical problems
PO2:	An ability to write and present a substantial technical report/document
PO3:	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4:	An ability to design, test, analyze/diagnose insulation for high voltage apparatus.
PO5:	Able to design, analyze and optimize the power system and high voltage engineering system using modern optimization and simulation tools.

Mapping of POs to PEOs

Program Outcomes (PO's)	Program Education Objectives (PEOs)		
	PEO1	**PEO2**	**PEO3**
PO1	3	3	3
PO2	2	3	3
PO3	3	2	2
PO4	3	2	2
PO5	2	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak

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COURSE STRUCTURE

I-SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1	MT-HVE-1101	Generation and Measurement of High Voltages High Voltage Laboratory	PC	3	0	3	4.5
2	MT- HVE-1102	Dielectrics and Insulation Engineering	PC	3	0	0	3
3	**Program Elective-1:**		PE	3	0	0	3
	MT- HVE-1103	i. Artificial Intelligent Techniques					
	MT- HVE-1104	ii. HVDC Transmission					
	MT- HVE-1105	iii. Outdoor High Voltage Insulators					
4	**Program Elective-2:**		PE	3	0	0	3
	MT- HVE-1106	**i.** High Voltage Power Apparatus and Diagnostics					
	MT- HVE-1107	ii. Smart Grid Technologies					
	MT- HVE-1108	iii. Advanced Electrical Insulation Systems					
5	MT- HVE-1109	Research Methodology and IPR	CC	2	0	0	2
6	MT- HVE-1110	Simulation Laboratory – I	LB	0	0	3	1.5
7	MT- HVE-1111	Audit Course-1*	AC	2	0	0	0
		Total Credits					17

Student has to choose any one audit course listed below.

II SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1	MT- HVE-1201	High Voltage Testing Techniques Advanced High Voltage Laboratory	PC	3	0	3	4.5
2	MT- HVE -1202	Surge Phenomenon & Insulation Coordination	PC	3	0	0	3
3	**Program Elective-3:**		PE	3	0	0	3
	MT- HVE-1203	i. Partial Discharge in HV Equipment					
	MT- HVE-1204	ii. Gas Insulated Systems and Substations					
	MT- HVE-1205	iii. Condition Monitoring of high voltage Power Equipment					
4	**Program Elective-4:**		PE	3	0	0	3
	MT- HVE-1206	i. EHVAC Transmission					
	MT- HVE-1207	ii. Flexible AC Transmission Systems					
	MT- HVE-1208	iii. Renewable Energy Sources and Systems					
5	MT- HVE-1209	Simulation Laboratory – II	LB	0	0	3	1.5
6	MT- HVE-1210	Mini Project with Seminar	MP	2	0	0	2
7	MT- HVE-1211	Audit Course-2 *	AC	2	0	0	0
		Total Credits					17

Two months Mandatory Industrial Training/Internship during summer / semester break

Student has to choose any one audit course listed below.

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Audit Course 1 & 2:

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India

~~5. Pedagogy Studies~~
~~6. Stress Management by Yoga~~
~~7. Personality Development through Life Enlightenment Skills~~

III-SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1.	**Program Elective-5:**		PE	3	0	0	3
	1. MOOCs (NPTEL) - 12 Week Course recommended by the department						
	2. Courses offered by the department in the college:						
	MT- HVE-2101	i. Fundamentals of Electric Vehicles.					
	MT- HVE-2102	ii. Nano Dielectrics.					
	MT- HVE-2103	iii. Energy Auditing, Conservation and Management.					
2.	**Open Elective:**		OE	3	0	0	3
	1.MOOCs (NPTEL/SWAYAM)-Any 12 Week Course on Engineering/ Management/ Mathematics offered by other than parent department						
	2. Courses offered to other departments in the college*:						
	MT- HVE-2104	i. Concepts of Internet of Things					
	MT- HVE-2105	ii. Concepts of Smart Grid Technologies.					
3.	MT- HVE-2106	**Internship** *(Performed during summer / I year break)*		-	-	-	2
4.	MT- HVE-2107	**Dissertation-Part I/ Industrial Project part I#**	PJ	0	0	20	10
Total Credits							18

#Students going for Industrial Project/Thesis will complete these courses through MOOCs

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

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

IV SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1	MT- HVE -2201	**Dissertation-Part II/ Industrial Project part II**	PJ	0	0	32	16
Total Credits							16

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M.Tech. I-Semester

COURSE CODE – MT-HVE-1101	GENERATION & MEASUREMENT OF HIGH VOLTAGES	CATEGORY PC	L-T-P 3 -0-3	CREDITS 4.5

Pre-requisite: Electrical & Electronics circuits, Basic measurement techniques.

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

		Knowledge Level (K)#
CO1	Suggest suitable techniques for the generation of high AC and DC voltages	5
CO2	Suggest suitable techniques for the generation of impulse voltages and currents.	5
CO3	Measure high DC and AC voltages.	4
CO4	Measure high AC peak voltages, impulse voltage, and currents	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	2	2
CO2	1	1	2	2	2
CO3	2	2	2	3	3
CO4	2	2	3	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**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 – 2	**Generation of Impulse Voltages:** Impulse voltages: 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 – 3	**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 – 4	**Measurement of Peak and impulse Voltages:** 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	

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	systems-generalized voltage measuring circuits-transfer characteristics of measuring circuits-L.V. Arms for voltage dividers-compensated dividers.	
UNIT – 5	**Measurement Impulse Currents:** 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, McGraw-Hill Books Co., New Delhi, 2nd edition, 1995.

Reference Books:

1. High Voltage Engineering – New Age International (P) Limited, Publishers, Second Edition, New Delhi, 2007
2. High Voltage Measuring Techniques – A. Schwab MIT Press, Cambridge, USA, 1972.

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M.Tech. I-Semester

COURSE CODE – MT-HVE-1101	HIGH VOLTAGE LABORATORY	CATEGORY PC	L-T-P	CREDITS

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	List of Experiments
1	Breakdown test of transformer oil with uniform and non-uniform fields
2	Breakdown characteristics of rod-rod gap
3	Breakdown characteristics of point-sphere gap
4	Breakdown characteristics of sphere-sphere gap
5	Breakdown characteristics of plane-rod-gap
6	Breakdown characteristics of point-plane gap
7	Generation and measurement of standard impulse voltages
8	Measurement of Leakage current and insulation resistance of polypropylene scale
9	Measurement of Leakage current and insulation resistance of polypropylene rope
10	Measurement of leakage current and breakdown voltage of porcelain disc insulator
11	Measurement of leakage current and breakdown voltage of polymer insulator
12	Measurement of Leakage current and breakdown voltage of pin insulator

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Attended Online	Attended Online	Attended Online	

M.Tech. I-Semester

COURSE CODE – MT-HVE-1102	DIELECTRICS AND INSULATION ENGINEERING	CATEGORY PC	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.	4
CO2	Illustrate the properties and applications of various insulating materials.	2
CO3	Demonstrate the breakdown phenomenon in gas and vacuum insulation.	3
CO4	Demonstrate the breakdown phenomenon in liquid and solid insulation.	3
CO5	Recommend a technique for the numerical evaluation of high-voltage apparatus.	5

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	---	1	3	1
CO2	2	---	1	2	1
CO3	3	---	2	3	2
CO4	3	---	2	3	2
CO5	3	---	3	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Dielectrics and Insulating Materials**: 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	

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	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	**Numerical techniques:** Finite Difference Method, Finite Element Method, Boundary Element Method and Charge Simulation Method.	
	Total	**48 Hrs**

Text Books:

1. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata McGraw-Hill Books Co., New Delhi, 2nd edition, 1995.
2. Insulating Materials-by Dekker,S. Chanda & Co
3. High Voltage Engineering – by E.Kuffel and W.S. Zaegnl Pergamon press, Oxford, 1984.

Reference Books:

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

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M.Tech. I-Semester

COURSE CODE – PJ HVE-1103	ARTIFICIAL INTELLIGENT TECHNIQUES (PROGRAM ELECTIVE–1)	CATEGORY PE	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 different models of artificial neurons & Use learning methods of ANN.	4
CO2	Evaluate different paradigms of ANN.	5
CO3	Classify between classical and fuzzy sets.	4
CO4	Illustrate different modules of Fuzzy logic controller.	3
CO5	Apply fuzzy logic for the fault diagnosis and condition assessment of high voltage apparatus.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	--	2	1	1
CO2	2	--	2	2	2
CO3	1	--	1	1	1
CO4	2	--	1	2	2
CO5	2	--	3	2	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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,	

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	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** Artificial-intelligence techniques for incipient fault diagnosis and condition assessment: Database for condition assessment- Fuzzy-logic fault diagnosis-Asset analysis and condition ranking-Equipment ranking according to the insulation Condition-Insulation health index	
	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.
3. R.E.James and Q Su,"Condition Assessment of High Voltage Insulation in Power System Equipment",IET Power and Energy series 53, 2008.

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.
4. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam, SSumathi, S N Deepa TMGH
5. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam, SSumathi, S N Deepa Springer, 2007.

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M.Tech. I-Semester

COURSE CODE –MT-HVE - 1104	HVDC TRANSMISSION (PROGRAM ELECTIVE–1)	CATEGORY PE	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	Discuss about advantages, power handling capabilities of HVDC links and understand the components of HVDC converter station	2
CO2	Illustrate the operation of 6-pulse and 12-pulse bridge converters	3
CO3	Demonstrate various control schemes of HVDC converters and systems	3
CO4	Examine the interaction between HVAC and HVDC systems and compare Multiterminal DC system	4
CO5	Analyze various converter faults and protection schemes of HVDC systems	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	1	-	1
CO2	2	-	2	-	-
CO3	2	-	2	-	1
CO4	2	-	2	-	1
CO5	2	-	2	1	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Typical layout of HVDC transmission system and role of equipment involved, Comparison of AC and DC transmission: Economics of transmission, technical performance. Limitations of EHV AC Transmission, Advantages and limitations of HVDC transmission, Reliability of HVDC systems, Types of HVDC links	
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. Voltage and current harmonics in HVDC. Harmonic elimination using Filters.	

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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 HVDC 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. VSC based HVDC converter principle and operation, components of VSC	
	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.
4. Dragan Jovcic, Khaled Ahmed, High voltage direct current transmission: converters, systems and DC Grids, Wiley publications 2015.

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M.Tech. I-Semester

COURSE CODE – MT HVE - 1105	OUTDOOR HIGH VOLTAGE INSULATORS (PROGRAM ELECTIVE–1)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of Power systems

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

		Knowledge Level (K)#
CO1	Summarize various types of insulators and their characteristics.	2
CO2	Demonstrate the electrical considerations of outdoor high-voltage insulators.	3
CO3	Demonstrate the environmental and material considerations of outdoor high voltage insulators.	3
CO4	Recommend an insulator by considering electrical, mechanical and physical characteristics.	5
CO5	Select a pollution mitigation technique by considering the environmental factors.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	---	2	1	1
CO2	2	---	2	2	---
CO3	2	---	2	2	2
CO4	3	---	3	3	---
CO5	3	---	3	2	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Insulator Types and Characteristics:** Insulator Materials: Porcelain, Toughened glass, Epoxy resin, Polymer composites, Fundamental Physical Aspects: Dry Arcing distance, Creepage distance, Insulator class. Insulator Types: Pin insulator, Line post insulator, Composite line post insulator, Cap-and-pin (disc) insulator, Long rod insulator, Composite long rod insulator, Station post insulator, Pedestal post insulator, Bushing, Apparatus (hollow) insulator, Stay (guy) wire insulator, Guy strain insulator - Insulator Sheds - Insulator End Fittings, Voltage distribution of a string insulator, String efficiency.	
UNIT– 2	**Electrical Considerations** Dry and Wet Power Frequency Flashover - Lightning and Switching Impulse Flashover - Power Frequency Pollution Flashover- Other Electrical Considerations: Risk of puncture, Corona, Resistance to power arc damage, Snow and ice flashover, Instantaneous or rapid conductive fog flashover, Bird streamer flashover Lightning-induced back flashovers, Voltage transfer,	

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Attended Online	Attended Online	Attended Online	

	Temporary Over Voltages (TOV)	
UNIT– 3	**Environmental & Material Considerations** Pollution: Pre-deposit pollution, Instantaneous pollution, Pollution sources - Weather- Site Severity Assessment: Surface pollution deposit technique - Other pollution assessment methods Other Environmental Considerations: Bird streamers, Birds, rodents and termites, Soil resistivity, Seismic activity, Corrosion, Vandalism. Porcelain: Porcelain manufacture and properties, Construction of porcelain insulators. Glass: Glass manufacture and properties, Construction of glass insulators Polymeric Insulators : Composite insulators, Resin insulators - Metal Fittings	
UNIT– 4	**Insulator Selection and Specification** Insulator Type and Material: Pollution types and severity, Lightning severity, Vandalism - Insulator Characteristics: Electrical characteristics, Mechanical characteristics, Physical characteristics- Insulator Selection Chart Insulator Specification.	
UNIT– 5	**Pollution Mitigation Techniques** Insulator Replacement, Cleaning, Silicone Greasing, RTV Coating, Creepage / Shed Extenders, Insulator Upgrading, Mitigation Method Selection	
	Total	**48 Hrs**

Text Books:

1. The practical guide to outdoor high voltage insulators – by W L Vosloo et al, crown publications – 2004.
2. Ravi S. Gorur, "Outdoor Insulators", Inc. Phoenix, Arizona 85044, USA, 1999 Working Group D1.44, "Pollution test of naturally and artificially contaminated insulators" Cigre 2017

Reference Books:

1. Looms, J.S.T., "Insulators for High Voltages", IET, London, U.K 1988.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier
   India Pvt. Ltd, 2005
3. Kind and Karner, "High Voltage Insulation", Translated from German by Y.Narayana Rao,
   Frider. Vieweg, &Sohn, Braunschweig, Weishaden, 1985.
4. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, McGraw-Hill Books Co., New Delhi, 5th edition..

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M.Tech. I-Semester

COURSE CODE – MT-HVE - 1106	HIGH VOLTAGE POWER APPARATUS AND DIAGNOSTICS (PROGRAM ELECTIVE–2)	CATEGORY PE	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Knowledge on Transformers & Fourier Transforms

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

		Knowledge Level (K)#
CO1	Illustrate important components of the power transformer, reasons of failure of transformer.	3
CO2	Calculate tan delta, resistivity and capacitance of transformer oil.	4
CO3	Illustrate the concept of moisture in transformer oil and paper, detect the partial discharges using various detection methods	3
CO4	Analyze the relation between DP and furfural content, also investigate the faults in a transformer using Dissolved gas analysis.	4
CO5	Analyze the frequency response of transformer winding with Fourier Transformer	4

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	---	---	3	1	--
CO2	2	---	1	1	1
CO3	2	---	3	2	---
CO4	1	---	3	1	1
CO5	---	---	3	2	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction to power transformer, important components of power transformer, winding configuration, cooling of winding. Reasons of failure of transformer, overvoltage due to switching operation, over-voltage due to lightning impulse, over voltage due to fault, 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 moisture reduction, winding resistance, Influence with regard to life of transformer. Partial Discharges in transformer, causes of	

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Attended Online	Attended Online	Attended Online	

	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	
UNIT – 4	Degree of polymerization (DP) of transformer paper, effect of DP on life of transformer, furfural content in oil insulation, inter – relationship between degree of polymerization and furfural content, Dissolved gas analysis in transformer oil, various gas product in transformer oil, tolerable level of gases in transformer on load , Various detection of important gases in transformer, Faults identification using various methods	
UNIT – 5	Fourier Transform and frequency response analysis of transformer winding, concept of Fourier Transformer with regard to configuration of 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 office Page 1-602
2. Sivaji Chakrovorti, DEbangshuDey, Biswendu Chatterjee," Recent trends in the condition monitoring of transformers", Springer-Verlag, London 2013

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

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Attended Online	Attended Online	Attended Online	

M.Tech. I-Semester

COURSE CODE – MT-HVE-1107	SMART GRID TECHNOLOGIES (PROGRAM ELECTIVE–2)	CATEGORY PE	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	Describe smart grids and explain the smart grid policies and developments in smart grids.	2
CO2	Demonstrate the concepts of smart grid technologies for home and electrical applications.	3
CO3	Illustrate the usage of GIS, IED, SMES, WAMS, and PMU etc. for smart grids.	3
CO4	Demonstrate the integration of Distributed energy resources with micro grids	3
CO5	Analyze the effect of power quality in smart grid and understand latest developments in ICT for smart grid.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	--	2	--	--
CO2	2	--	2	--	2
CO3	3	--	2	--	2
CO4	2	--	3	--	2
CO5	2	--	3	--	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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,	

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	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. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
2. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "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

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M.Tech. I-Semester

COURSE CODE – MT-HVE-1108	ADVANCED ELECTRICAL INSULATION SYSTEMS (PROGRAM ELECTIVE–2)	CATEGORY PE	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	Identify the insulating material based on the requirements of the electrical system.	2
CO2	Choose an HVAC insulation system for transformers, cables, and other high voltage equipment,	5
CO3	Choose insulation systems for HVDC and Impulse voltages	5
CO4	Analyze the various problems associated with space charge accumulation in HVDC insulation.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	---	1	2	1
CO2	1	---	3	3	2
CO3	1	---	2	3	2
CO4	1	---	3	3	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Insulating Materials:** Gases: air and SF_6 - Inorganic Solid Insulating Materials- Highly Polymerized Plastics: Thermoplastic Insulating Materials, Thermosetting Materials and Elastomers, Silicones- Insulating Liquids: Mineral Oil, Vegetable oil and Natural Easter Liquids, Liquefied gases- Fibrous Material: Paper and Pressboard, Synthetic Fibrous Materials	
UNIT– 2	**Typical Insulation systems for AC Voltages:** Cables: Paper-insulated Cables, Plastic-insulated Cables, Gas-insulated Lines (GIL)- Bushings: Field Grading or Potential Grading, Calculation of Capacitive Grading- Transformers: Oil-filled Transformers and Dry-type Transformers, Reactors, Windings and On-load Tap Changer- Capacitors: Structure of the Dielectric, Drying and Impregnation – Circuit breakers: SF_6 Compressed gas Circuit breaker, Vacuum Circuit breaker	
UNIT– 3	**Typical Insulation systems for DC Voltages:** Electrical Stress and Strength for DC Voltage: Dielectric Stresses and Strength at DC Voltage, Dielectric Properties of Materials -Capacitors for Direct Voltage (DC Capacitors) - HVDC Transformers: Dielectric Stresses,	

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	AC and Steady-state DC Voltage Stresses, Stresses during Voltage Variations - HVDC Bushings: Internal Insulation, External Insulation - HVDC Cables: DC Cables, Paper-insulated HVDC Cables, Plastic-insulated HVDC Cables.	
UNIT– 4	**Typical Insulation systems for Impulse Voltages:** Electrical Stress and Strength- Energy Storage- Impulse Capacitors (Energy Storage or Surge Capacitors): Capacitor Design, Capacitor Inductance, Dielectric and Service Life,– other applications: Lightning Protection, Electrostatic Particle Precipitation, Ionization	
UNIT– 5	**Space Charges in HVDC insulation** Space Charge in HVDC Cable Insulation, Space-Charge Accumulation, Charge Generation, Charge Trapping, Thermal Methods: Laser Intensity Modulation Method (LIMM), Thermal Pulse Method, Thermal Step Method (TSM), Pressure Pulse Methods: Pressure Wave Propagation Method, Laser-Induced Pressure Pulse (LIPP) Method, Pulsed Electroacoustic (PEA) Method	
	Total	**48 Hrs**

Text Books:

1. Kuchler, High Voltage Engineering-Fundamentals, Technology and Application, Springer,2017.
2. R. Aurora, W. Mosch, High Voltage and Electrical Insulation Engineering, Wiley, 2011
3. Du, Polymer Insulation Applied for HVDC Transmission, Springer 2020.
4. Giovanni Mazzanti, Massimo Marzinotto, Extruded Cables for High Voltage Direct Current Transmission Wiley Publication, June 2013.

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Attended Online	Attended Online	Attended Online	

M.Tech. I-Semester

COURSE CODE – PAT - HVE - 1110	SIMULATION LABORATORY – I	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5

Pre-requiste: Concepts of high voltage generation and Dielectric materials

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

		Knowledge Level (K)#
CO1	Analyze the Electric Field Intensity for the uniform and non-uniform fields	4
CO2	Analyze the Electric Field Intensity at all the crucial areas of the insulators	4
CO3	Execute impulse voltage and current generation circuits using modern simulation tools	3
CO4	Execute tesla coil circuit using modern simulation tools.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	1	1
CO2	3	2	3	3	3
CO3	1	1	3	1	2
CO4	1	1	3	---	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

List of Experiments

S.No.	CONTENTS
1	Electric Field Analysis of Sphere to Sphere gap
2	Electric Field Analysis of Rod to Rod gap.
3	Electric Field Analysis of Point to Sphere gap.
4	Electric Field Analysis of Plane to Rod gap.
5	Electric Field Analysis of Disc Insulator.
6	Electric Field Analysis of 11kV Polymer Insulator.
7	Electric Field Analysis of Pin Insulator.
8	Simulation of Impulse voltage generation circuit.
9	Simulation of Impulse current generation circuit.
10	Simulation of Tesla coil circuit.

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M.Tech. II-Semester

COURSE CODE – PMT-HVE-1201	HIGH VOLTAGE TESTING TECHNIQUES	CATEGORY PC	L-T-P 3-0-3	CREDITS 4.5

Pre-requisite: Basics of high voltage engineering.

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

		Knowledge Level (K)#
CO1	Identify the suitable non-destructive testing technique for high voltage and high current applications	2
CO2	Analyze the electrical, mechanical, and pollution performances of the dielectric materials and high-voltage apparatus by conducting suitable tests as per standards.	4
CO3	Demonstrate various high-voltage AC testing methods and differentiate between laboratory testing and in-service performances.	3
CO4	Evaluate the performance of the various high voltage power equipment with their suitable impulse testing procedures.	5
CO5	Calibrate the PD detectors and Analyze the performance of the power apparatus by choosing a suitable partial discharge measurement method.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	2	1	---
CO2	3	2	3	3	2
CO3	1	1	2	2	---
CO4	3	2	3	3	2
CO5	1	1	2	2	---

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Week)

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 – Measurement of string efficiency.	
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.	

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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.
3. High Voltage Engineering – by C.L.Wadhwa, New Age International Pvt Ltd Publishers -3rd edition.
4. Outdoor insulators – by Ravi S. Gorur, Edward A.Cherney, Jeffrey T. Burnham, "Outdoor Insulators", Ravi S. Gorur, Inc., Phoenix, Arizona85044,USA,1999.

Reference Books:

1. Discharge Detection in H.V. Equipment – by KREUGER, F.H. Haywood London – 1964.
2. Ryan H.M. and Whiskand: design and operation perspective of British UHV Lab IEE pre 133 H.V. Testing Techniques Halfly
3. The practical guide to outdoor high voltage insulators – by W L Vosloo et al, crown publications – 2004.
4. Insulators for high voltages by J.S.T. Looms by IET power and energy series

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M.Tech. II-Semester

COURSE CODE – HVE-1201	ADVANCED HIGH VOLTAGE LABORATORY	CATEGORY PC	L-T-P	CREDITS

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	List of Experiments
1	Voltage distribution across a suspension insulator string
2	Wet power frequency testing on polymer insulator string
3	Dry lightning impulse testing on polymer insulator string
4	Wet switching impulse testing on polymer insulator string
5	Artificial contamination testing on porcelain insulator string
6	Generation and measurement of non-standard impulse voltages
7	Incline plane tracking testing on polymer material
8	Contact angle measurement of water molecule on polymer material
9	Tensile testing on polymer insulator
10	Corona testing on insulator string
11	Measurement of Resistivity, Equivalent Salt Deposit Density (ESDD) and Non-soluble deposit density (NSDD) of polluted water sample
12	Millivolt drop test and Tong tester calibration
13	Measurement of tan delta and dielectric constant

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – MT-HVE-1202	SURGE PHENOMENON AND INSULATION COORDINATION	CATEGORY PC	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	Observe the behavior of travelling waves in transmission systems.	2
CO2	Illustrate the effect of insulation capacitance and transient response of lines and systems with distributed parameters.	3
CO3	Analyze the causes and protection of lightning/switching over voltages in the power systems.	4
CO4	Analyze the causes and protection of surge voltages induced in the transformer windings.	4
CO5	Demonstrate the insulation coordination and Illustrate the operations of over voltage protective devices.	3

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	---	1	2	1
CO2	3	---	2	2	2
CO3	3	---	2	3	3
CO4	2	---	2	3	2
CO5	2	---	2	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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	

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	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).

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE –MT-HVE-1203	PARTIAL DISCHARGE IN HV EQUIPMENT (PROGRAM ELECTIVE–3)	CATEGORY PE	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.	4
CO2	Compute the partial discharges in solid dielectrics.	3
CO3	Analyze the detection of discharges using different detection circuits.	4
CO4	Locate and evaluate the partial discharges in electrical apparatus and systems.	5
CO5	Detection of partial discharges in various instruments.	3

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	---	1	2	1
CO2	1	---	2	2	---
CO3	1	---	2	3	---
CO4	3	---	3	3	1
CO5	2	---	2	2	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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,	

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	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
3. High Voltage Engineering – by E.Kuffel and W.S.Zaengl. Pergaman press Oxford, 1984.

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – 19T-HVE-1204	GAS INSULATED SYSTEMS AND SUBSTATIONS (PROGRAM ELECTIVE–3)	CATEGORY PE	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	Illustrate the Properties of SF_6 gas used in GIS.	3
CO2	Compare Gas Insulated Substation with Air Insulated Substations.	4
CO3	Analyze the design aspects and effect of very fast transient over voltages on the Gas Insulated Substations.	4
CO4	Perform the different types of tests on GIS, to diagnosis it's condition.	3
CO5	Analyze Fast Transient Phenomena in GIS.	3

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	---	2	---	---
CO2	---	---	2	2	---
CO3	---	---	2	3	2
CO4	2	---	2	3	2
CO5	2	---	2	3	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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, Design Features, Estimation of Different types of Electrical Stresses, Design Aspects of GIS Components, Insulation Design for GIS, Thermal Considerations in the Design of GIS,	

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	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 in Insulation, Insulation Diagnostic Methods, PD Measurement, UHF Method, 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 and 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.

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – MT-HVE-1205	CONDITION MONITORING OF HIGH VOLTAGE POWER EQUIPMENT (PROGRAM ELECTIVE–3)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics concepts of power systems and dielectrics

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

		Knowledge Level (K)#
CO1	Illustrate the modes of deterioration, failure and electrical stress distribution of the practical insulating materials.	3
CO2	Analyze the insulation defects in various power system equipment's.	4
CO3	Analyze the insulation defects in rotating machines and demonstrate various non-destructive electrical measurement methods.	4
CO4	Investigate various physical and chemical diagnostic methods and demonstrate the operation of various sensors used for condition monitoring of insulation	4
CO5	Analyze various online insulation condition monitoring techniques.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	---	3	3	2
CO2	3	---	2	2	---
CO3	3	---	3	3	---
CO4	3	---	3	3	---
CO5	3	---	3	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction:** Need for Condition monitoring, Predictive maintenance, Characterization of insulation condition, Modes of deterioration and failure of practical insulating Materials, Overview of insulation design requirements, Electric stress distributions in simple insulation systems and Electric stress control.	
UNIT – 2	**Insulation defects in power-system equipment**-Suspension and post insulators, High-voltage bushings, High-voltage instrument transformers, High-voltage power capacitors, High-voltage surge arresters, High-voltage circuit breakers, Gas-insulated systems, High-voltage cables.	
UNIT – 3	**Insulation defects in rotating machines-** Possible insulation failure mechanisms in rotating machines. **Insulation defects in Transformers.** **Non-destructive electrical measurements**-Insulation resistance (IR) measurements-Measurements of the dielectric dissipation factor (DDF)-	

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	Measurement of partial discharges by electrical methods-Dielectric response measurements	
	Physical and chemical diagnostic methods-Indicators of in-service condition of oil–paper Systems-Analysis of SF6 samples from GIS-Surface deterioration of composite insulators-Water treeing in XLPE cable insulation-Ultrasonic methods for detection of partial discharges. **Sensors for insulation condition monitoring**-Ultra-high-frequency sensors, Optical-fibre sensors, Directional sensors for PD measurements	
UNIT – 5	**Online insulation condition monitoring techniques**-problems with offline condition monitoring, Noise-mitigation techniques, Non-electrical online condition monitoring, Online acoustic/electric PD location methods for transformers, Electrical online condition monitoring and periodic monitoring	
	Total	**48 Hrs**

Text Books:

1. R.E.James and Q Su,"Condition Assessment of High Voltage Insulation in Power System Equipment",IET Power and Energy series 53, 2008.
2. Sivaji Chakrovorti, DEbangshuDey, Biswendu Chatterjee," Recent trends in the condition monitoring of transformers", Springer-Verlag, London 2013.

Reference Books:

1. T.S. Ramu, Partial Discharge Based Condition Monitoring of High Voltage Equipment, New age International Publishers,2010.

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M.Tech. II-Semester

COURSE CODE – MT-HVE-1206	EHVAC TRANSMISSION (PROGRAM ELECTIVE–4)	CATEGORY PE	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.	3
CO2	Calculate the field effects on EHV and UHV AC lines.	3
CO3	Determine the corona, RI and audible noise in EHV and UHV lines.	2
CO4	Analyze voltage control and compensation problems in EHV and UHV transmission systems.	4
CO5	Compare different reactive power compensation devices	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	---	3	2	1
CO2	3	---	3	3	3
CO3	2	---	2	3	2
CO4	2	---	3	2	2
CO5	2	---	3	2	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Week)

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 in the space - 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.	

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Attended Online	Attended Online	Attended Online	

UNIT – 3	Corona : Corona in EHV lines – corona loss formulae –exact loss formula using charge voltage diagram, 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. Ultra-high Voltage AC/DC power transmission – Hao Zhou et al., Springer publishers - 2018

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – MT-HVE-1207	FLEXIBLE AC TRANSMISSION SYSTEMS (PROGRAM ELECTIVE–4)	CATEGORY PE	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.	2
CO2	Get the knowledge of effect of static shunt and series compensation.	3
CO3	Illustrate the use of SVC and STATCOM for Shunt Compensation.	3
CO4	Determine an appropriate FACTS device for different types of applications.	4
CO5	Know the principle of operation and various controls of UPFC & IPFC	2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	---	1	---	---
CO2	2	---	2	---	2
CO3	3	---	2	---	2
CO4	3	---	2	---	2
CO5	3	---	2	---	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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	

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	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
2. FACTS Controllers in Power Transmission and Distribution, K.R. Padiyar, New Age International Publishers, 2016
3. Thyristor- Based FACTS controllers for electrical transmission systems, R. Mohan Mathur and Rajiv K. Varma, IEEE Press, 2002

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

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – MT-HVE-1208	RENEWABLE ENERGY SOURCES AND SYSTEMS (PROGRAM ELECTIVE–4)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of Power Systems

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

		Knowledge Level (K)#
CO1	List out various economic and managerial aspects of renewable energy systems.	2
CO2	Analyze the operation of induction generator for wind power generation.	4
CO3	Illustrate various functional components of wind power plants.	3
CO4	Analyze various MPPT controllers techniques for solar power generation.	4
CO5	Analyze the operations of fuel cells, Tidal energy, Biomass and Geothermal Energy systems.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	--	1	--	--
CO2	2	--	1	--	--
CO3	2	--	1	--	--
CO4	2	--	2	--	--
CO5	2	--	3	--	--

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Week)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** Renewable Sources of Energy; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Control of renewable energy based power Systems	
UNIT– 2	**Wind Power Plants:** Site Selection; Evaluation of Wind Intensity; Topography; Purpose of the Energy Generation- General Classification of Wind Turbines; Rotor Turbines; Multiple-Blade Turbines; Drag Turbines; Lifting Turbines - Generators and Speed Control Used in Wind Power Energy;	
UNIT– 3	**Wind mill Generators:** Principles of Operation of Induction Generators, Doubly Fed Induction Generator, Permanent Magnet Synchronous Generator. Analysis of Small wind energy conversion system. Integration of wind power plant into the grid. MPPT for wind power plants.	
UNIT– 4	**Photovoltaic Power Plants:** Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell on Temperature and irradiance	

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	input-output Characteristics - Equivalent Models and Parameters for Photovoltaic Panels; MPPT schemes: P&O, INC, effect of partial shaded condition. Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy. Integration of Photovoltaic power plant into the grid.	
UNIT– 5	**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. **Tides**: Basic principle of Tide Energy, Components of Tidal Energy, Advantages and limitations of Tidal power Generation. **Biomass and Geothermal Energy:** Introduction, Biomass conversion technologies, classification of biogas plants, advantages and their disadvantages, Types of biogas plants	
	Total	**48 Hrs**

Text Books:

1. Felix A. Farret, M. Godoy Simo` es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

Reference Books:

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.

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Attended Online	Attended Online	Attended Online	

M.Tech. II-Semester

COURSE CODE – PT-HVE-1209	SIMULATION LABORATORY – II	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5

Pre-requisite: Concepts of High voltage and Renewable energy sources

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

		Knowledge Level (K)#
CO1	Design and evaluate various high voltage generating circuits and resonance circuit using modern simulating tools	5
CO2	Analyze the effect of stray capacitance on the high voltage dividers.	4
CO3	Analyze the performance curves of PV module and array with varying the temperatures and irradiances.	4
CO4	Analyze the effect of partial shading condition and MPPT technique operation of a PV module	4
CO5	Design and analyze the performance curves of a wind turbine generator using modern simulating tools	4

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	2	2
CO2	2	1	3	2	1
CO3	2	2	2	---	2
CO4	2	2	2	---	2
CO5	2	1	2	---	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

List of Experiments

Any 10 of the following experiments are to be conducted

S.NO.	CONTENTS
1	Simulation of Cockroft-Walton Voltage Multiplier circuit
2	Simulation of Voltage doubler circuit
3	Simulation of Resonance circuit
4	Study the effect of stray capacitance on the high voltage dividers.
5	Simulation of Marx 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 its performance curves.
9	Analyze the effect of partial shading condition of a PV module.
10	Simulate the Maximum Power Point tracking of PV module using INC Algorithm.

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Attended Online	Attended Online	Attended Online	

M.Tech III-Semester

COURSE CODE –PT-HVE-201	FUNDAMENTALS OF ELECTRIC VEHICLES (PROGRAM ELECTIVE–5)	CATEGORY PE	L-T-P 3-0-0	CREDITS 3

Course Outcomes: After the completion of the course the student should be able to:

		Knowledge Level (K)#
CO1	Describe different types of electric vehicles.	2
CO2	Illustrate the components of Electric vehicles	3
CO3	Differentiate among series, parallel and complex Electric vehicles	3
CO4	Present the need and merits of V2G and G2V Technologies	3
CO5	Demonstrate the battery management system for Electric vehicle system	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	2	-	-
CO2	2	-	2	-	-
CO3	2	-	3	-	-
CO4	3	-	2	-	2
CO5	2	-	2	-	2

(Please fill the above with Levels of Correlation - viz. - L-1 - M-2 - H-3)

UNIT	CONTENTS	Contact Hours
UNIT - 1	**Introduction** Fundamentals of vehicles - Components of conventional vehicles - drawbacks of conventional vehicles – Need for electric vehicles - History of Electric Vehicles – Types of Electric Vehicles – Advantages and applications of Electric Vehicles.	
UNIT - 2	**Components of Electric Vehicles** (EVs) Main components of Electric Vehicles – Power Converters - Controller and Electric Traction Motor – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters.	
UNIT - 3	**Hybrid Electric Vehicles** Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs - Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples - Merits and Demerits.	
UNIT - 4	**V2G and G2V Technologies** Energy scenario in India, Electricity consumption by EVs and all other loads, End of life batteries for grid support, EV charging schemes, types of EV chargers, Vehicle-to-grid (V2G) and Grid-to-Vehicle (G2V) technologies, Energy trading with EVs.	

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Attended Online	Attended Online	Attended Online	Kdl

UNIT - 5	**Energy Sources for Electric Vehicles** Batteries - Types of Batteries – Lithium-ion - Nickel-metal hydride - Lead-acid – Comparison of Batteries - Battery Management System – Ultra capacitors – Flywheels – Fuel Cell – it's working.	
	Total	

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Denton - Tom. Electric and hybrid vehicles. Routledge - 2020.

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

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M.Tech III-Semester

COURSE CODE – PAT-HVE-2102	NANO DIELECTRICS (PROGRAM ELECTIVE–5)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Dielectric Insulation Engineering

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

		Knowledge Level (K)#
CO1	Illustrate the variation of dielectric and insulating properties of materials with nanofiller addition.	3
CO2	Analyze the various applications of nanofillers in electric power and electronic sectors.	4
CO3	Analyze the thermal and mechanical performances of Nanocomposite insulating materials.	4
CO4	Evaluate the structures of Nanofiller Interfaces.	5
C05	Evaluate the performance of Nanocomposites by various computer simulation methods and analyze risk evaluation.	5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	---	3	1	---
CO2	3	---	3	3	2
CO3	3	---	3	2	1
CO4	3	---	3	3	3
CO5	3	---	3	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction** Methods of Mixing Quasi-Cubic Nanofillers, Methods of Mixing Layered Nanofillers, Change in Dielectric and Insulating Properties with Nanofiller Addition, Thermal Expansion Coefficient, Thermal Expansion Coefficient and withstanding Electric Stress	
UNIT– 2	**Applications in Electric Power and Electronics Sectors:** Power Apparatus and Cables-Space Charge Accumulation Is a Big Nuisance for DC Transmission Cables, Nanocomposite XLPE Insulated Power Cables. Polymer Insulators for Outdoor Use- Improvement of Erosion Resistance and Bonding in Interfaces using Nanocomposites and Nanofiller Addition Sealing resins for semiconductor devices and packaging	
UNIT– 3	**Thermal and Mechanical Performance of Nanocomposite Insulating Materials:** Transformation of Epoxy Resin Thermal Characteristics with the use of Nanofiller, Effects of several types of nanofillers on the glass transition temperature, Dispersion of thermal Characteristics of Several Types of Polymers by the Nanofillers- Room Temperature Vulcanizing silicones, Polypropylene,	

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	Polyethylene **Mechanical Performance-** Improvement of Tensile Strength, Flexure Performance and Suppression of Propagation of Crack by Nanofiller Addition.	
	Structures of Polymer/Nanofiller Interfaces: Interfaces, Interfaces Formed by Inorganic Fillers and Organic Polymers, Interfacial Models- two-layered interfacial model, Multi-core model, Physicochemical Analysis Methods for Interfaces- Evaluation of Shapes, Sizes and Dispersion by SEM and TEM, Estimation of Filler Content by Measuring the Density of Nanocomposites.	
UNIT– 5	**Computer Simulation Methods to Visualize Nanofillers in Polymers-** Non-Empirical Molecular Orbital Method, Simulation of Performance of Nanocomposites by Coarse-Grained Molecular Dynamics **Environmental Concerns-** Effects of Nanofillers on Human Body and Environment, Risk Evaluation of Nanofillers	
	Total	**48 Hrs**

Text Book:

1. Advanced Nanodielectrics Fundamentals and Applications, by Toshikatsu Tanaka and Takahiro Imai, PAN Stanford Publications,2017.
2. Nanoporous materials: Advance techniques for characterization, Modeling and Processing Edited by Nick KanelloPoulos. CRC press, 2011.

Reference Books:

1. Handbook of Nanofabrication. Edited by Gary Wiederrcht. Elsevier, 2010.
2. Nanocomposite Science and Technology: by P.M. Ajayan, L.S. Schadler, P.V.Braun, 2003 WILEY-VCH Verlag GmbH Co. KGaA, Weinheim.
3. Inorganic Nanoparticles: Synthesis, Application and Perspectives. Edited by Claudia Altavilla and Enrico Ciliberto. CRC Press, 2011.
4. Polymer nanocomposites: by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
5. CRC Handbook of Thermoelectrics, Ed. CR Rowe.

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M.Tech III-Semester

COURSE CODE – PAT-HVE-2103	ENERGY AUDITING, CONSERVATION AND MANAGEMENT (PROGRAM ELECTIVE-5)	CATEGORY PE	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	Discuss the principle of energy audit and their economic aspects.	2
CO2	Report the energy management planning and reporting	2
CO3	Recommend energy efficient motors and design good lighting system.	5
CO4	Summarize the power factor improvement methods and energy instruments	2
CO5	Evaluate the depreciation of equipment.	5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	2	--	2	--	1
CO2	1	--	3	--	1
CO3	2	--	3	--	2
CO4	3	--	2	--	2
CO5	2	--	2	--	2

(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**	

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	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

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M.Tech III-Semester

COURSE CODE –PT-HVE-2104	CONCEPTS OF INTERNET OF THINGS (Open Elective)	CATEGORY OE	L-T-P 3 -0-0	CREDITS 3

Pre-requisite:

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

		Knowledge Level (K)#
CO1	Review Internet of Things (IoT).	
CO2	Demonstrate various business models relevant to IoT.	
CO3	Construct designs for web connectivity	
CO4	Organize sources of data acquisition related to IoT, integrate to enterprise systems.	
CO5	Describe IoT with Cloud technologies.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1		---			
CO2		---			
CO3		---			
CO4		---			
CO5		---			

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

UNIT	CONTENTS	Contact Hours
UNIT – 1	**The Internet of Things-** An Overview of Internet of things, Internet of Things Technology, behind IoTs Sources of the IoTs, Examples OF IoTs, Design Principles For Connected Devices, Internet connectivity, **Application Layer Protocols-** HTTP, HTTPS, FTP	
UNIT – 2	Business Models for Business Processes in the Internet of Things, IoT/M2M systems LAYERS AND designs standardizations, Modified OSI Stack for the IoT/M2M Systems, ETSI M2M domains and High-level capabilities, Communication Technologies, Data Enrichment and Consolidation and Device Management Gateway Ease of designing and affordability.	
UNIT – 3	Design Principles for the Web Connectivity for connected-Devices, Web Communication protocols for Connected Devices, Message Communication protocols for Connected Devices, Web Connectivity for connected-Devices.	
UNIT – 4	Data Acquiring, Organizing and Analytics in IoT/M2M, Applications/Services/Business Processes, IOT/M2M Data Acquiring and Storage, Business Models for Business Processes in the Internet Of Things, Organizing Data, Transactions, Business Processes, Integration and Enterprise	

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	Systems.	
UNIT – 5	Data Collection, Storage and Computing Using a Cloud Platform for IoT/M2M Applications/Services, Data Collection, Storage and Computing Using cloud platform Everything as a service and Cloud Service Models, IOT cloud-based services using the Xively (Pachube/COSM), Nimbits and other platforms Sensor, Participatory Sensing, Actuator, Radio Frequency Identification, and Wireless, Sensor Network Technology, Sensors Technology, Sensing the World.	
	Total	**48 Hrs**

Text Books:

1. Internet of Things: Architecture, Design Principles And Applications, Rajkamal, McGraw Hill Higher Education
2. Internet of Things, A.Bahgya and V.Madisetti, Univesity Press, 2015

Reference Books:

1. Designing the Internet of Things, Adrian McEwen and Hakim Cassimally, Wiley.
2. Getting Started with the Internet of Things, CunoPfister , Oreilly

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M.Tech III-Semester

COURSE CODE – PT – HVE-2105	CONCEPTS OF SMART GRID TECHNOLOGIES (OPEN ELECTIVE)	CATEGORY OE	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
CO1		---			
CO2		---			
CO3		---			
CO4		---			
CO5		---			

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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,	

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	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. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, AkihikoYokoyama,"Smart Grid: Technology and Applications", Wiley
2. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "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

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