EE306: HIGH VOLTAGE ENGINEERING
CREDITS = 5 (L=3, T=0, P=2)

Course Objective:
The subject aims to provide the student of electrical disciplines with:

1. To clearly understands the basic concepts of high voltage generation, measurement and testing techniques.
2. To understand the properties, applications and conduction and breakdown phenomena in various classes of insulation materials.
3. Knowledge for learning advanced topics in high voltage engineering.
4. To learn the software for high voltage engineering education.

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
L	T	P	C	Theory		Practical		Total Marks
				ESE	CE	ESE	CE	
3	0	2	5	70	30	30	20	150

Course Contents:

Unit No	Topics	Teaching Hours.
1.	**Electrical breakdown in gases:**	06

Gases as insulating media - ionization and decay processes, Townsend first ionization coefficient, photo-ionization, ionization by interaction of meta-stable with atoms, thermal ionization, deionization by recombination, deionization by attachment–negative ion formation, mobility of gaseous ions and deionization by diffusion, relation between diffusion and mobility, examples - cathode processes.

Secondary effects, photoelectric emission, electron emission by positive ion and excited atom impact, thermionic emission, field emission, Townsend second ionization coefficient, secondary electron emission by photon impact, examples.

Transition from non-self-sustained discharges to breakdown, the Townsend mechanism, examples - the streamer or ‘kanal’ mechanism of spark, examples - the sparking voltage.

Paschen’s law, penning effect, the breakdown field strength, and breakdown in non-uniform fields - effect of electron attachment on the breakdown criteria, partial breakdown, corona discharges, and polarity effect – influence of space charge - practical gaseous dielectrics: SF_6, SF_6 mixtures, vacuum, gas insulated substations.

2. **Breakdown in liquid and solid dielectrics:** 06

Liquid as insulators, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, cavity breakdown, electro-convection and electro-hydrodynamic model of dielectric breakdown, examples.
Transformer oil filtration, transformer oil test.
Breakdown in solids, intrinsic breakdown, streamer breakdown, electromechanical breakdown, edge breakdown and treeing, thermal breakdown, erosion breakdown, tracking - breakdown of solid dielectrics in practice, solid dielectrics used in practice.

3. **Generation of high voltages:** 10

Generation of high direct voltages, half and full wave rectifier circuits, voltage multiplier circuits, Van de Graff generators, electrostatic generators, examples.
Generation of high alternating voltages, high voltage testing transformers, cascaded transformers, resonant transformers, examples.
Impulse voltages, impulse voltage generator circuits, Marx circuit, operation, design and construction of impulse generators, examples - impulse current generator - control systems.

4. **Measurement of high voltages:** 08

High direct current voltage measurement, peak voltage measurements by spark gaps, sphere gaps, reference measuring systems, uniform field gaps, rod gaps, factors affecting sphere gap measurements, examples – electrostatic voltmeters - ammeter in series with high ohmic resistors and high ohmic resistor voltage dividers - generating voltmeters and field sensors – the measurement of peak voltages, the Chubb–Fortescue method, high-voltage capacitors for measuring circuits - voltage dividing systems and impulse voltage measurements, generalized voltage generation and measuring circuit, voltage dividers, interaction between voltage divider and its lead, the divider's low-voltage arm - digital recorders, errors inherent in digital recorders.

5. **Over voltages, testing procedures and insulation coordination:** 06

The lightning mechanism, energy in lightning, nature of danger, switching surge test voltage characteristics.
Insulation coordination, insulation level, statistical approach to insulation coordination, correlation between insulation and protection levels –brief overview of lightning arresters.

6. **Non-destructive insulation test techniques:** 04

Measurement of dielectric loss and capacitance measurements, the Schering bridge, partial-discharge (PD) measurements, the basic PD test circuit, PD currents, PD measuring systems within the PD test circuit, measuring systems for apparent charge, sources and reduction of disturbances, other PD quantities, calibration of PD detectors in a complete test circuit, digital PD instruments. Introduction of SFR Test.

7.	**High voltage testing:** Testing of insulators and bushings – testing of isolators, testing of cables – testing of transformers – testing of surge diverters – radio interference measurements. Design, planning and layout of high voltage laboratory.	04
8.	**Introduction to software:** Software applications to high voltage engineering field.	02
	TOTAL	**46**

Reference Books:

1. Kuffel, E., Zaengl W.S., Kuffel J., "High Voltage Engineering: Fundamentals"Butterworth-Heinmann (A division of Reed Educational & Profession Publishing Limited), 2nd Edition, 2000.
2. Naidu M. S. and Kamaraju V., "High Voltage Engineering", fourth Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2009.
3. Wadhwa C.L., "High Voltage Engineering", third edition, New Age publishers, New Delhi, 2010.
4. Ravindra Arora and Wolfgang Mosch, "High Voltage - Insulation Engineering", first edition, New Age International Publishers Limited, New Delhi, 2002.
5. Rakosh Das Begamudre, "High Voltage Engineering, Problems and Solutions", New Age International Publishers, New Delhi, 2010.
6. Dieter Kind, Kurt Feser, "High Voltage Test Techniques", Reed educational and professional Publishing Ltd. (Indian edition), New Delhi-2001.
7. Muhammad H. Rashid, "Introduction to Pspice Using OrCAD for circuits and electronics", Third Edition, Pearson Education.
8. Paul Tobin, Pspice for Circuit Theory and Electronic Devices, Morgan and Claypool publishers.

Web Material:

1.http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT KANPUR/HighVoltageEngg/ui/TOC.html

Course Outcomes (COs):

After study this subject students will be able to:

CO1.Understand how to formulate basic problems and model the associated configurations, circuits and systems related to high voltage components and systems.
CO2.Deal with high voltage systems and networks and solve basic problems related to generation, measurement and testing.
CO3. Understand properties of various insulating materials.
CO4.Understand the design planning and layout of high voltage laboratory.