Nirma University

Institute:	**Institute of Technology**
Name of Programme:	**B.Tech. in Electrical Engineering**
Semester:	**V**
Course Code:	**3EE202ME24**
Course Title:	**High Voltage Engineering**
Course Type:	**Department Elective-I**
Year of Introduction:	**2024 – 2025**

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Course Learning Outcomes (CLOs):

At the end of the course, students will be able to –

1. illustrate the phenomenon of electrical breakdown in various insulation (BL2)
2. apply high voltage and high current generation and measurement techniques (BL3)
3. select appropriate testing method for diagnostics of insulation (BL5)
4. evaluate diagnostic inferences using descriptive statistical techniques (BL5)

Unit	Contents	Teaching Hours (Total 45)
Unit-I	**Electrical breakdown in insulation** Breakdown in Gases- Mechanisms of breakdown in gases, related ionization processes, Townsend and streamer theory, Paschen's law, breakdown in non-uniform fields, effect of wave shape of impressed voltage on the breakdown strength, breakdown of sphere gap and rod gap Breakdown in solids - intrinsic breakdown, electromechanical breakdown, thermal breakdown, edge and erosion breakdown – treeing & tracking, composite dielectric breakdown, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, bubble and cavity breakdown, models of dielectric breakdown, various breakdown theories, transformer oil purification	**12**
Unit – II	**Generation and Measurement of high voltages and current** Direct voltages, voltage doubler circuits, Cockcroft Walton circuit, electrostatic generators, alternating voltages, cascade transformers, series resonant circuits, Tesla coils, impulse voltages - impulse voltage generator circuits, operation and design, control systems, impulse current generation - circuits, operation and design. Peak voltage measurements by spark gaps - sphere gaps, uniform field gaps, rod gaps, electrostatic voltmeters, ammeter in series with high ohmic resistors and high ohmic resistor voltage dividers, generating voltmeters, the Chubb–Fortescue method, high voltage capacitors for measuring circuits, voltage dividing systems and impulse voltage measurements, effect of lead, impulse current measurement, Rogowski coil	**10**
Unit-III	**Non-destructive insulation test techniques** Dynamic properties of dielectrics, modelling of dielectric properties, DC resistivity measurement, complex permittivity, dielectric loss (tan delta) and capacitance measurements, RIV measurement, SFRA technique - concept,	**07**

procedure, inference, partial discharge (PD) concept, apparent charge, measurement circuits, concept of dissolved gas analysis (DGA) – key gas method, Duval's triangle, relevant standards and guidelines

Unit-IV **Design, Planning and Layout of High Voltage Laboratories** **02**

High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, shielding and grounding of high voltage laboratories

Unit-V **Over Voltages and Insulation Co-ordination** **06**

Lightning, switching and temporary over voltages, traveling wave phenomena, Bewley's lattice diagram. BIL, SIL, methods of insulation coordination, graded insulation in a power system

Unit-VI **Statistical Techniques for High Voltage Engineering** **08**

Basic concepts of probability theory, distribution functions, selected theoretical distribution functions, fundamentals of corelation and regression, selected test methods

Self-Study: The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings/ References:

- Kuffel, Zaengl and Kuffel, *High Voltage Engineering Fundamentals*, Newnes Publications.
- Wadhwa C L, *High Voltage Engineering*, New Age Publications.
- Alston L L, *High Voltage Technology*, Oxford University Press.
- Naidu M S and Kamraju V, *High Voltage Engineering*, Tata McGraw Hill Publications.
- Hauschild, Wolfgang, and Wolfgang Mosch., *Statistical techniques for high-voltage engineering*. No. 13. IET.
- Begamudre R D, *High Voltage Engineering Problems and Solutions*, New Age International Publishers.
- Dieter Kind, *High Voltage Test Technique*, Newnes Publisher.
- Sivaji Chakravorti, Debangshu Dey, Biswendu Chatterjee, *Recent Trends in the Condition Monitoring of Transformers*, Springer.
- Recent technical literature, journal articles.

Suggested List of Experiments: Laboratory work will be based on the above syllabus with a minimum 10 experiments to be incorporated. The students in a suitable group size will design and perform one experiment as a part of laboratory work.

Sr. No.	Name of Experiment	Hours
1.	Introduction to High Voltage laboratory equipment and different High Voltage control panels.	2
2.	To plot electric field of various electrode geometries using electrolytic tank.	2
3.	To determine the breakdown characteristics of air for different shapes of electrodes.	2
4.	To measure dielectric strength of insulating oil.	2
5.	To determine breakdown voltage for different types of solid insulating materials.	2
6.	To observe the movement of impurities in liquid dielectric under the influence of electric stress.	2
7.	To explore the working of horn gap type lightning arrester.	2

8.	To perform flashover test on 11 kV pin type insulator.	2
9.	To study the components, control and operation of 300kV, 3kJ impulse generator and observe the impulse waveform on digital storage oscilloscope.	2
10.	To perform frequency response measurement of transformer model.	2
11.	To measure dielectric constant of different dielectric / insulating liquids.	2
12.	To study the operation of Tesla coil.	2