B.P. PODDAR INSTITUTE OF MANAGEMENT AND TECHNOLOGY
137, VIP Road, PoddarVihar, Kolkata: 7000052
Department of Electrical Engineering
Academic Year -2025-26 (Odd Semester)
LESSON PLAN

Program : Electrical Engineering Credit: 3 Contact: 3L
Course Name : High Voltage Engineering
Course Code : PE EE 501A
Course Coordinator: Dr. Argha Kamal Pal

Lectures Number	Topics to be covered	Text Books / Reference	Teaching Pedagogies
L1	Introduction to Breakdown of Gases • Basic concept of electrical breakdown • Mechanism of breakdown in gases • Ionization and electron avalanche • Charge multiplication process	T1, R2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L2	Townsend Breakdown Theory • Primary ionization coefficient • Secondary emission process • Townsend first and second ionization coefficients • Townsend breakdown criterion	T1, R2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L3	Streamer Breakdown Theory • Limitations of Townsend theory • Streamer mechanism • Formation and propagation of streamer	T1, R2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L4	Paschen's Law • Paschen's law derivation and characteristics • Paschen curve • Determination of minimum breakdown voltage	T1, R2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L5	Breakdown in Non-Uniform Electric Field • Breakdown characteristics in non-uniform fields • Corona discharge • Effect of polarity on corona inception and breakdown voltage	T1, R2, P2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L6	Partial Discharge • Definition of partial discharge • Mechanism of partial discharge	T1, R2, W2, W3	1. Lecture 2. Quiz 3. Power Point Presentation
L7	Breakdown of Solid Dielectrics • Intrinsic breakdown • Electromechanical breakdown	T1, R2, P1, W1	1. Lecture 2. Quiz 3. Power Point Presentation

L8	Breakdown of Solid Dielectrics • Thermal breakdown • Streamer breakdown in solids	T1, R2, P1	1. Lecture 2. Quiz 3. Power Point Presentation
L9	Breakdown of Liquid Dielectrics • Intrinsic breakdown of liquids • Cavitation theory • Suspended particle theory	T1, R2, P2	1. Lecture 2. Quiz 3. Power Point Presentation
L10	Breakdown in Vacuum • Non-metallic electron emission mechanism • Clump mechanism • Effect of pressure on breakdown voltage	T1, R1, P1	1. Lecture 2. Quiz 3. Power Point Presentation
L11	Introduction to High Voltage Generation • Need for generation of high voltages in laboratories • Applications of high DC, AC, and impulse voltages • Basic methods of generating high voltages	T1, T2, R2, W2	1. Lecture 2. Quiz 3. Power Point Presentation
L12	Generation of High DC Voltages • Principle of rectification • Half-wave rectifier circuit for high DC voltage generation • Circuit diagram, operation, and limitations	T1, W2, R2	1. Lecture 2. Quiz 3. Power Point Presentation
L13	Generation of High DC Voltages • Cockcroft–Walton voltage multiplier circuit • Working principle • Voltage multiplication stages • Advantages and limitations	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L14	Electrostatic Generator • Principle of electrostatic generation • Van de Graaff generator (working and construction) • Applications in high voltage testing	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L15	Generation of High AC Voltages • Cascaded transformers • Principle of cascade connection • Series resonant circuit for high AC voltage generation • Advantages and applications	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L16	Generation of Impulse Voltages • Need for impulse voltage testing • Standard impulse wave shapes (Lightning impulse and switching impulse) • Parameters of impulse waves (front time, tail time)	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation

L17	Multistage Impulse Generators • Principle of multistage impulse generator (Marx generator) • Charging and discharging process • Generation of switching surges	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L18	Generation of Impulse Currents and Control • Generation of impulse currents • Impulse current circuits and applications • Tripping and control of impulse generators	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L19	Introduction to High Voltage Measurement • Need for measurement of high voltages and currents • Classification of high voltage measurement methods • Direct and indirect measurement techniques	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L20	Sphere Gap Method • Principle of sphere gap measurement • Construction and working • Factors affecting measurement accuracy • Applications and limitations	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L21	Uniform Field Spark Gap • Concept of uniform electric field • Uniform field spark gap arrangement • Voltage measurement using uniform field spark gaps	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L22	Rod Gap Method • Construction and working of rod gaps • Voltage measurement using rod gaps • Advantages and limitations	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L23	Electrostatic Voltmeter • Principle of electrostatic force • Construction and working of electrostatic voltmeter • Advantages and applications in HV measurement	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L24	Generating Voltmeter • Principle of generating voltmeter • Construction and working mechanism • Applications in measuring high	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation

	DC voltages		
L25	Impulse Voltage Measurement • Impulse voltage measurement techniques • Voltage dividers (resistive and capacitive) • Basic measurement setup in HV laboratories	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L26	Measurement of High Currents and Recording Instruments • Measurement of high DC currents • Measurement of impulse currents • Cathode Ray Oscillographs (CRO) for impulse voltage and current measurements	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L27	Introduction to Lightning Phenomena • Nature and characteristics of lightning • Electrification of clouds • Charge distribution in clouds	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L28	Development of Lightning Stroke • Mechanism of lightning stroke • Stepped leader and return stroke • Types of lightning strokes	T1, W2, R2	1. Lecture 2. Online video lectures 3. Power Point Presentation
L29	Lightning-Induced Overvoltages • Lightning induced overvoltage • Direct lightning stroke • Indirect lightning stroke • Effects on power systems	T1, W2, R1	1. Lecture 2. Online video lectures 3. Power Point Presentation
L30	Protection Against Overvoltages • Need for protection of electrical apparatus against overvoltages • General protection methods • Introduction to lightning arresters	T1, W2, R1	1. Lecture 2. Online video lectures 3. Power Point Presentation
L31	Types of Lightning Arresters • Valve type lightning arrester • Metal oxide lightning arrester • Expulsion type lightning arrester • Working principles and comparison	T1, W2, R1	1. Lecture 2. Online video lectures 3. Power Point Presentation
L32	Protection of Transformers and Substations • Effect of location of lightning arresters on transformer protection • Protection of substations • Ground wires and shielding methods	T1, W2, R1	1. Lecture 2. Power Point Presentation

L33	Insulation Coordination • Concept of insulation coordination • Basic Insulation Level (BIL) • Basic Impulse Level and Switching Impulse Level	T1, W2, R1	1. Lecture 2. Power Point Presentation
L34	Protective Device Characteristics and BIL Determination • Volt-time characteristics of protective devices • Determination of Basic Impulse Level of substation equipment	T1, T2, R1	1. Lecture 2. Power Point Presentation
L35	Standards for High Voltage Testing • Importance of standards in high voltage testing • Overview of Indian Standards (IS) and International Electrotechnical Commission (IEC) standards • General testing procedures for electrical apparatus	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation
L36	Testing of Insulators and Bushings • Types of insulator tests (power frequency test, impulse test, flashover test) • Testing procedures for bushings • Significance of these tests in power systems	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation
L37	Testing of Isolators and Circuit Breakers • High voltage testing of isolators • Dielectric tests for circuit breakers • Impulse and power frequency tests for switching devices	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation
L38	Testing of Cables and Power Transformers • High voltage testing of cables • Insulation tests for power transformers • Routine and type tests	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation
L39	Testing of Cables and Power Transformers • High voltage testing of cables • Insulation tests for power transformers • Routine and type tests	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation
L40	High Voltage Laboratory Layout • Layout of high voltage laboratories • Indoor and outdoor HV laboratories • Basic testing facility requirements	T1, T2, R2, W1	1. Lecture 2. Power Point Presentation

Text Books:

T1. High Voltage Engineering, C.L. Wadhawa, New Age International Publishers.B. P. Lathi, Communication Systems, BS Publications.

T2. High Voltage Engineering, M.S. Naidu & V. Kamraju, Tata MC Graw Hill publication.

Reference Books:

R1. High-Voltage Engineering : theory and practice, Mazen Abdel-Salam; Hussein Anis; Ahdab El-Morshedy; RoshdyRadwan, New York, N.Y. : Marcel Dekker, ©2000.

R2. High Voltage Engineering, E. Kuffel, W.S. Zaengl, J. Kuffel, 2nd edition, Butterworth-Heinemann.

Research Papers:

P1: Chakraborty, R., Reddy, B.S.: Performance of silicone rubber insulators under thermal and electrical stress. Paper presented at electrostatics joint conference, Purdue University, West Lafayette, June 2016.

P2: Pal AK, Baral A, Lahiri A. Studies on prospect of HTV silicone rubber as dielectric material when reinforced with TiO2 nano particles. IET Sci Meas Technol. 2021;1–10. https://doi.org/10.1049/smt2.12030

P3: Tanaka, T.: Dielectric nanocomposites with insulating properties. IEEE Trans. Dielec. Elect. Insul. 12, 914–928 (2005)

Web References:

W1. https://nptel.ac.in/courses/108104048

W2. https://www.youtube.com/playlist?list=PLwymdQ84KI-yYkfuc1NB5WCtekWoCxkzZ

W3. https://www.youtube.com/playlist?list=PLm_MSClsnwm9dOy25lZgEqZD-r3EEDS6L