

HIGH VOLTAGE ENGINEERING
(ELEC 4231)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group - A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) The value of Townsends second ionization coefficient has
(a) high value for low E/p ratio (b) low value for low E/p ratio
(c) no relation with E/p ratio (d) no application if the gas pressure is low.
- (ii) All the parameters remaining same, the breakdown voltage is
(a) higher with negative polarity at all pressures
(b) lower with negative polarity at all pressures
(c) higher with negative polarity at low pressures
(d) higher with negative polarity at high pressures.
- (iii) The electric field in a gas bubble which is immersed in a liquid of permittivity ϵ_r is
(a) higher than that of the field in the liquid
(b) lower than that of the field in the liquid
(c) same as that in the liquid
(d) none of the above.
- (iv) Paper insulation is mainly used in
(a) cables and capacitors (b) transformers
(c) rotating machines (d) circuit breakers.
- (v) The dielectric strength of air under normal conditions is around
(a) 30 kV per cm (b) 100 kV per cm
(c) 150 kV per cm (d) 60 kV per cm.
- (vi) An impulse voltage wave defined by its
(a) wave front time
(b) wave tail time
(c) both wave front and wave tail time
(d) wave front time, wave tail time and peak of its waveform.

- (vii) Time lag for breakdown is
 - (a) time taken for the voltage to rise before breakdown occurs
 - (b) time difference between instant of applied voltage and occurrence of breakdown
 - (c) time required for gas to breakdown under pulse application
 - (d) none of these.

- (viii) For impulse generator circuit
 - (a) the first sphere gap is slightly less than the second and so on
 - (b) the first sphere gap is slightly higher than the second and so on
 - (c) all the sphere gap remain same
 - (d) none of the above.

- (ix) The mechanism responsible for dielectric loss in a dielectric are
 - (a) conduction
 - (b) polarization
 - (c) ionization
 - (d) (b) and (c).

- (x) A generating voltmeter uses
 - (a) a constant speed motor
 - (b) a variable speed motor
 - (c) a variable speed motor with a capacitor
 - (d) a constant speed motor with a capacitor.

Group- B

- 2. (a) Compare between Townsend's theory of gaseous breakdown and Streamer mechanism of gaseous breakdown. [(CO1)(Apply/IOCQ)]
 - (b) Explain Paschen's Law curve with diagram. [(CO1)(Understand/LOCQ)]
 - (c) A steady current of 500 μ A flowing through the plane electrode separated by a distance of 0.6 cm when a voltage of 500 V is applied. Determine the Townsend's first ionization co-efficient if a current of 50 nA flows when the distance of electrode separation is reduced to 0.2 cm and the field is kept constant at the previous value. [(CO1)(Evaluate/HOCQ)]

6 + 3 + 3 = 12
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- 3. (a) Develop the expression of dielectric voltage required to cause breakdown of the void in solid insulation material. [(CO1)(Apply/IOCQ)]
 - (b) A solid insulating block of thickness 1.5 cm and having a dielectric constant of 4.5 is subjected to a 50 Hz ac voltage. The specimen contains an air void of thickness 1 mm. considering the breakdown strength of air as 30 kV/cm (peak), Determine the maximum voltage which can be applied across the specimen without any internal discharge. [(CO1)(Evaluate/HOCQ)]
 - (c) Explain the phenomenon of treeing in solid insulating materials? [(CO1)(Remember/LOCQ)]

6 + 3 + 3 = 12

Group - C

4. (a) Build the Cockroft-Walton voltage multiplier circuit from voltage doubler circuit. [(CO2)(Apply/IOCQ)]
(b) Explain the operation of the Cockroft-Walton voltage multiplier circuit for generation of high D.C voltage. [(CO2)(Understand/LOCQ)]
(c) A ten stage Cockroft-Walton circuit has all capacitors of 0.06 μ F. The secondary voltage of the supply transformer is 100 kV at a frequency of 150 Hz. If the load current is 1 mA, determine (i) voltage regulation (ii) ripple (iii) the optimum number of stages for maximum output voltage (iv) the maximum output voltage. [(CO2)(Evaluate/HOCQ)]
4 + 4 + 4 = 12
5. (a) Develop the expressions of ripple voltage and voltage drop in a n-stage Cockroft-Walton circuit. [(CO2)(Apply/IOCQ)]
(b) Justify from the expressions obtained in (a) that the lowest capacitors are most responsible for the ripple and voltage drop. [(CO2)(Evaluate/HOCQ)]
(c) Explain the principle of operation of Van De Graaff Generator with neat diagram [(CO2)(Understand/LOCQ)]
6 + 2 + 4 = 12

Group - D

6. (a) Explain the Chubb-Fortescue method for the measurement of peak value of AC voltages with neat diagrams. [(CO3)(Understand/LOCQ)]
(b) Compare the circuit operations of Series Impedance voltmeter and Series capacitance voltmeter. [(CO3)(Analyse/IOCQ)]
(c) An electrostatic voltmeter has a movable circular plate 8 cm in diameter. If the distance between the plates during a measurement is 4 mm, determine the potential difference when the force of attraction is 0.2 gm wt. [(CO3)(Evaluate/HOCQ)]
4 + 5 + 3 = 12
7. (a) Explain the principle of operation of Electrostatic Voltmeter with necessary diagrams. [(CO3)(Understand/LOCQ)]
(b) Compare the performance of Series Capacitance Voltmeter and Capacitance Potential Divider. [(CO3)(Analyse/IOCQ)]
(c) A generating voltmeter is required to measure voltage between 15 kV to 250 kV. If the indicating meter reads a minimum current of 2 μ A and maximum of 35 μ A, determine the capacitance of the generating voltmeter. Assume that the speed of driving of synchronous motor is 1500 rpm. [(CO3)(Evaluate/HOCQ)]
4 + 6 + 2 = 12

Group - E

8. (a) Define Insulation Coordination. [(CO5)(Remember/LOCQ)]

- (b) A surge of 15 kV magnitude travels along a cable towards its junction with an overhead line. The inductance and capacitance of the cable and overhead line are respectively 0.3 mH, 0.4 μ F and 1.5 mH, 0.012 μ F per km. Determine the voltage rise at the junction due to the surge. [(CO5)(Evaluate/HOCQ)]
- (c) List the different tests carried out on Bushings with brief explanation of each of them. [(CO4)(Analyse/IOCQ)]
- 2 + 4 + 6 = 12**
9. (a) Compare between valve type Lightning Arrester and Metal-oxide Lightning Arrester. [(CO5)(Analyse/IOCQ)]
- (b) Explain the Type Tests to be conducted in a Power Capacitor. [(CO4)(Understand/LOCQ)]
- 6 + 6 = 12**
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	46.88	21.87

Course Outcome (CO):

After the completion of the course students will be able to

1. Understand the basic physics related to breakdown processes in solid, liquid and gaseous insulating materials.
2. Learn the methods of generation of D. C., A.C., & Impulse voltages and their measurements.
3. Learn the methods of measurements of D. C., A.C., & Impulse voltages & currents.
4. Perform tests on H. V. equipments and insulating materials, as per the standards.
5. Explain the developments of voltage surges in power system and the operation of the related protective devices.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question