HIGH VOLTAGE ENGINEERING
(ELEC 4231)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) An impulse voltage wave is define by
(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.

(ii) 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 gas pressure is low

(iii) SF_6 gas is a
(a) electro positive gas
(b) electro negative gas
(c) inert gas
(d) any one of the above

(iv) The voltage regulation of testing transformer is generally
(a) positive value
(b) negative value
(c) zero
(d) All of these

(v) In Cockroft Walton voltage doubler circuit the voltage across the capacitor connected across the load may varies from
(a) $2V_m$ to $1.8V_m$
(b) $2V_m$ to $-2V_m$
(c) $2V_m$ to V_m
(d) $2V_m$ to 0

(vi) The breakdown voltage for air gap of 3 mm in a uniform field under standard atmospheric condition is

(a) 10.59 kV (b) 6.3 kV
(c) 9.2 kV (d) 7.25 kV

(vii) The velocity of a travelling wave through a cable of relative permittivity 9 is

(a) 9×10^8 m/sec (b) 3×10^8 m/sec
(c) 10^8 m/sec (d) 2×10^8 m/sec

(viii) An overhead line with surge impedance 400 ohms is terminated through a resistance R. A surge travelling over the line does not suffer any reflection at the junction if

(a) 20 ohms (b) 200 ohms
(c) 800 ohms (d) none of the above

(ix) High voltage Schering bridge is used to measure

(a) large capacitance without additional element
(b) small capacitance without additional element
(c) medium value capacitances
(d) all values of capacitances

(x) Partial discharge measurement on a cable gives

(a) p.f. of the cable (b) loss angle of the cable
(c) location of fault (d) (a) and (b)

Fill in the blanks with the correct word

(xi) Liquid dielectric with solid impurities has _____ the dielectric strength.

(xii) Electro negative gas has _____ dielectric strength than air at normal temperature and pressure.

(xiii) In series resonance circuit the low value of inductance is converted to high value by using _____.

(xiv) The breakdown voltage of a gaseous medium under uniform field gap is a function of the product of gap length and the _____

(xv) In case of a travelling wave , magnitude of transmitted current in open circuited condition of a transmission line is _____.

Group - B

2. (a) Develop Townsend's criterion of breakdown. *[(CO1) (Apply/IOCQ)]*
(b) Explain Paschen's Law curve with diagram. *[(CO1)(Understand/LOCQ)]*
(c) A steady current of 500μA flowing through the plane electrode separated by a distance of 0.4 cm when a voltage of 10kV applied. Determine the Townsend's first ionization co-efficient if a current of 60μA when the discharge separation is reduced to 0.1 cm and the field kept constant at the previous value. *[(CO1)(Evaluate/HOCQ)]*

7 + 2 + 3 =12

3. (a) How does the "internal PD" phenomenon lead to breakdown in solid dielectrics? *[(CO1)(Understand/LOCQ)]*

(b) Draw the schematic diagram that showing a simulated capacitance formed by the void within the solid insulation. *[(CO1)(Understand/LOCQ)]*

(c) Draw the PB voltages and pulse currents at a void in solid insulation. *[(CO1)(Understand/LOCQ)]*

(d) A 1.0 cm thick solid dielectric specimen having relative permittivity of 2.3 is subjected to high voltage in uniform field between the parallel-plate shaped electrodes. It has an internal horizontal void filled with air having a thickness of 1 mm. Estimate the PB inception voltage. *[(CO1)(Evaluate /HOCQ)]*

4 + 2 + 2 + 4 =12

Group - C

4. (a) Discuss any two methods to linearise the potential distribution across the transformer windings. *[(CO2)(Understand/LOCQ)]*

(b) Calculate the utilization factor of a three stage Cascaded transformer. *[(CO2)(Remember/LOCQ)]*

(c) Explain how the impulse voltage is being generated. *[(CO2) (Analyse/IOCQ)]*

5 + 3 + 4 = 12

5. (a) Describe with net diagram the working principle of Cockroft Walton voltage doubler circuit with schematic diagram. *[(CO2)(Understand/LOCQ)]*

(b) Write the four advantage of using the series resonance circuit to generate high voltage ac. *[(CO2)(Remember /LOCQ)]*

(5 + 3) + 4 = 12

Group - D

6. (a) With net sketch explain the working principle of electrostatic voltmeter. *[(CO3)(Understand/LOCQ)]*

(b) What are the requirements of a sphere gap for measurement of high voltage? *[(CO3)(Remember/LOCQ)]*

(c) Discuss the effect of dust particles on the measurements using sphere gap. *[(CO3)(Understand/LOCQ)]*

(d) An electrostatic voltmeter has two parallel plates. The movable plate is 10 cm in diameter. With 10 kV between the plates the pull is 5 × 10-3 N. Determine the change in capacitance for a movement of 1 mm of movable plate. *[(CO3)(Evaluate/HOCQ)]*

4 + 3 + 2 +3 = 12

7. (a) Explain the principle of operation of Generating Voltmeter for the measurement of high direct voltages with necessary diagrams. *[(CO3)(Understand/LOCQ)]*

(b) Determine the breakdown voltage for air gaps of 2 mm and 15 mm lengths under uniform field and standard atmospheric conditions. *[(CO3)(Evaluate/HOCQ)]*

(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 μA and maximum of 35 μA, determine the capacitance of the generating voltmeter. Assume that the speed of driving of synchronous motor is 1500 rpm. *[(CO3)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

Group - E

8. (a) Define Insulation Coordination. *[(CO5)(Remember/LOCQ)]*
   (b) A 500 kV 2 μ sec rectangular surge on a line having a surge impedance of 350 ohms approaches a station at which the earth capacitance is 3000 pF. Determine the maximum value of the transmitted wave. *[(CO5)(Evaluate/HOCQ)]*
   (c) Derive the expressions of Reflection Coefficients of Voltage and Current in case of a travelling wave. *[(CO5)(Analyse /IOCQ)]*
   (d) Compare between Type Tests and Routine Tests. *[(CO4) (Analyse/IOCQ)]*
   (e) What is flashover? *[(CO4)(Understand/LOCQ)]*

2 + 3 + 4 + 2 + 1 = 12

9. (a) Define a standard lightning overvoltage that is used for Laboratory testing. *[(CO4)(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 μF and 1.5 mH, 0.012 μF per km. Determine the voltage rise at the junction due to the surge? *[(CO5)(Evaluate/HOCQ)]*
   (c) Compare the current response characteristics of ZnO and SiC elements. *[(CO5)(Analyse/IOCQ)]*
   (d) Compare the volt-time characteristics of Rod-Gap and Expulsion type surge diverter. *[(CO5)(Analyse/IOCQ)]*
   (e) What is meant by atmospheric correction with reference to High Voltage Testing? *[(CO4)(Remember/LOCQ)]*

2 + 4 + 2 +2 + 2= 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	52.08	21.87	26.05

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.
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.*