

**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) For reducing tower footing resistance it is better to use
    - (a) Chemical and ground rods only
    - (b) chemical and counterpoise only
    - (c) ground rod and counterpoise only
    - (d) chemical, ground rod and counterpoise.
  - (ii) The velocity of a travelling wave through a cable of relative permittivity 9 is
    - (a)  $9 \times 10^8$  m/sec
    - (b)  $3 \times 10^8$  m/sec
    - (c)  $10^8$  m/sec
    - (d)  $2 \times 10^8$  m/sec.
  - (iii) 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 the value of R is
    - (a) 20 ohms
    - (b) 200 ohms
    - (c) 800 ohms
    - (d) none of (a), (b) & (c).
  - (iv) The insulation of the modern EHV lines is designed based on
    - (a) The lightning voltage
    - (b) The switching voltage
    - (c) Corona
    - (d) RI.
  - (v) Paper insulation is mainly used in
    - (a) Cables and capacitors
    - (b) Transformers
    - (c) Rotating machines
    - (d) Circuit breakers.
  - (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) Capacitance voltage divider can not be used for measuring high \_\_\_\_\_.  
(a) a.c voltage (b) d.c voltage  
(c) impulse voltage (d) all of (a), (b) & (c).
- (viii) Sphere gap voltmeter when measuring a.c voltage, it measures \_\_\_\_\_.  
(a) RMS value (b) average value  
(c) peak value (d) all of (a), (b) & (c).
- (ix) 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.
- (x) The mechanism responsible for dielectric loss in a dielectric are  
(a) conduction (b) polarization  
(c) ionization (d) (b) and (c).

### **Group- B**

2. (a) Derive the expression of self-sustained discharge when the gases follow the Townsend's mechanism of breakdown. *[[CO1](Understand/LOCQ)]*  
(b) Explain the Townsend's first and secondary ionization coefficients. *[[CO1](Understand/LOCQ)]*  
(c) A steady current of 500  $\mu$ A flows through the plane electrode separated by a distance of 0.6 cm when an electric field of 500 V is applied. Determine the Townsend's first ionization coefficient, if a current of 50 nA flows when the distance of electrode separation is reduced to 0.2 cm and the electric field is kept constant at the previous value. *[[CO1](Analyse/IOCQ)]*  
**4 + (2 + 2) + 4 = 12**
3. (a) Apply Townsend's criterion of breakdown to obtain Paschen's Law. *[[CO1](Apply/IOCQ)]*  
(b) A solid insulating block of thickness 1 cm and having a dielectric constant of 3.8 is subjected to a 50Hz ac voltage. The specimen contains an air void of thickness 1 mm. considering the breakdown strength of air as 30kV/cm (peak), Determine the voltage at which an internal discharge can occur. *[[CO1](Evaluate/HOCQ)]*  
(c) What do you mean by tracking in solid insulating materials? *[[CO1](Remember/LOCQ)]*  
**6 + 3 + 3 = 12**

### **Group - C**

4. (a) Describe with net diagram a three stage Cascaded transformer. Label the power rating of various stages of the transformer. *[[CO2](Remember/LOCQ)]*  
(b) Write the four differences between the power and testing transformer. *[[CO2](Remember/LOCQ)]*  
**(5 + 3) + 4 = 12**

5. (a) A cockroft-walton voltage doubler circuit is used to test a cable at 180 V. The insulation resistance of the cable is  $4 \times 10^9 \Omega/m$  and the length of the cable is 10m. Stage capacitance are both 0.1  $\mu F$ . The generator is supplied from a 230 V/250 V testing transformer. Calculate the voltage to be applied to the input of the transformer at 50Hz. [[CO2](Evaluate/HOCQ)]
- (b) Describe with net diagram the working principle of multi stage Max generator circuit. [[CO2](Understand/LOCQ)]

**6 + 6 = 12**

### Group - D

6. (a) What are the requirements of a sphere gap for measurement of high voltage? Discuss the effect of dust particles on the measurements using sphere gap. [[CO3](Understand/LOCQ)]
- (b) Compare the circuit operations of Series Impedance voltmeter and Series capacitance voltmeter. [[CO3](Analyse/IOCQ)]
- (c) An electrostatic voltmeter has two parallel plates. The movable plate is 10 cm in diameter. With 10 kV between the plates the pull is  $5 \times 10^{-3}$  N. Determine the change in capacitance for a movement of 1 mm of movable plate. [[CO3](Evaluate/HOCQ)]

**4 + 6 + 2 = 12**

7. Draw and discuss Chubb-Fortescue Circuit for measurement of peak value of a.c voltages and discuss its advantages over other methods. [[CO3](Analyse/IOCQ)]

**(3 + 6 + 3) = 12**

### Group - E

8. (a) Define a Surge Absorber. [[CO5](Remember/LOCQ)]
- (b) A surge of 100kV travelling in a line of natural impedance 600  $\Omega$  arrives at a junction of two lines of impedances 800  $\Omega$  and 200  $\Omega$  respectively. Find the surge voltages and currents transmitted into each of the branch lines. [[CO5](Evaluate/HOCQ)]
- (c) List the different tests carried out on Bushings. [[CO4](Analyse/IOCQ)]
- (d) Compare between Type Tests and Routine Tests. [[CO4](Analyse/IOCQ)]
- (e) Sketch an Impulse waveform with proper labelling. [[CO4](Analyse/IOCQ)]

**2 + 4 + 2 + 2 + 2 = 12**

9. (a) Sketch the volt-time curve of Expulsion Type Lightning Arrester. [[CO5](Apply/IOCQ)]
- (b) Compare a valve type Lightning Arrester and Metal-oxide Lightning Arrester with respect to their VI Characteristics. [[CO5](Analyse/IOCQ)]
- (c) What is flashover? [[CO4](Understand/LOCQ)]
- (d) List the names of different types of flashover tests. [[CO4](Analyse/IOCQ)]
- (e) What is Basic Insulation/Impulse Level (BIL)? [[CO4](Remember/LOCQ)]

**2 + 4 + 1 + 3 + 2 = 12**

<i>Cognition Level</i>	<i>LOCQ</i>	<i>IOCQ</i>	<i>HOCQ</i>
<i>Percentage distribution</i>	<i>39.58</i>	<i>44.79</i>	<i>15.63</i>

**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.*