THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

SEMESTER TWO FINAL EXAMINATION (2021)

EE404 HIGH VOLTAGE ENGINEERING

FINAL YEAR ELECTRICAL ENGINEERING – POWER (BEEP 4)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. You have **TEN (10) MINUTES** to read the paper.
   You must not begin writing during this time.

2. This is an **OPEN BOOK** Examination.

3. **Answer all questions.** All answers must be written in the **ANSWER BOOK** supplied.

4. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK – DO THIS NOW.**

5. Only drawing instruments, calculators and laptops with textbooks are permitted on your desk. NO phones allowed.

6. If you are found cheating in the Examination, the penalties specified by the University shall apply.

7. **TURN OFF** all Mobile Phone and place them on the floor under your seat before the start of Examination

Question 1 (20 marks)

(a) Describe briefly with the aid of suitable diagrams the avalanche process in the breakdown of gaseous dielectrics.

(b) Derive the Townsend's criteria for spark breakdown in a gaseous dielectric.

(c) Explain very briefly, considering the breakdown of gaseous dielectrics, why SF_6 is suitable in indoor substations.

(d) If the following measurements were made in a Townsend type discharge, determine the values of the Townsend's first and second ionization coefficients.

d (mm)	1	2	3	4	5	6	8	10	12	14	16
I (pA)	21	24	30	34	46	51	90	120	175	290	494

Question 2 (20 marks)

Describe briefly with the aid of suitable diagrams (where necessary) the following:

(a) breakdown mechanisms in commercial oil insulation

(c) thermal breakdown of a solid dielectric,

(d) breakdown due to internal discharges, and

(e) mechanism of lightning discharge.

Question 3 (20 marks)

(a) Compute the value of critical electric field (E_C) that would cause a break down in a transformer oil with water globule that would reach a condition of instability when β, the ratio of the longer to the shorter diameter of the spheroid, of about 1.85. For a water globule having R = 2.3 μm with surface tension σ = 43 dyne/cm, and ϵ_1 = 2.0 (transformer oil), ϵ_2 = 90 for water globule.

(b) In an experiment for determining the breakdown strength of transformer oil, the following observations were made. Determine the power law dependence between the gap spacing and the applied voltage of the oil.

Gap spacing (mm)	4	6	9	13
Voltage at breakdown (kV)	100	150	220	265

Question 4 (20 marks)

(a) A 132 –kV line is required to be used in PNG for transmission. Select the BIL and BSL, for a heavy pollution level of 49.3 kV/m in a volcanic aerosol prone environment. Determine the required number of string insulators for the vertical connected string insulation. The standard insulator size of dimension are of diameter of 254 mm and connection distance of 146 mm.

(b) Determine the required number of string insulators for the vertically connected string insulation. The standard insulator size of dimension are of diameter of 254 mm and connection distance of 146 mm.
(Use a standard BIL of 750 kV for the 132 kV system)

(c) What is the function of a surge arrester?

(d) What are the causes for switching and power frequency over-voltages? How are the power frequency overvoltages controlled in a power systems?

Question 5 (20 marks)

(a) A transmission line of surge impedance 500 Ω is connected to a cable of surge impedance 60 Ω at the other end. If a surge of 500 kV travels along the line to the junction point, find the voltage build-up at the junction?

(b) An underground cable of inductance, L = 0.25mH/km and C = 0.45 μF/km, is connected to an overhead line having inductance, L = 1.5 mH/km, and capacitance, C = 0.015 μF/km.

Calculate the transmitted and reflected voltage and current waves at the junction, if a surge of 100 kV travels to the junction,

(c) along the cable, and

(d) along the overhead line.

- END OF EXAM -