FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

ELECTRICITY AND MAGNETISM

ESG 1210

Final Examination Paper

April 2025

This examination paper consists of 4 printed pages.

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr. P. Sigwegwe

INSTRUCTIONS

ANSWER ALL PARTS OF QUESTION 1 IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

MARK ALLOCATION

QUESTION	MARKS
1.	**40**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
Maximum possible mark	**100**

Additional Requirements
Calculator
Constants
Permeability of free space $\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space $\epsilon_o = 8.85 \times 10^{-12}\ F\ m^{-1}$
Charge of an electron $e = 1.6 \times 10^{-19}\ C$
Mass of an electron $m_e = 9.11 \times 10^{-31}\ kg$
Mass of an proton $m_p = 1.67 \times 10^{-27}\ kg$

SECTION A

QUESTION 1

a) What are the fundamental characteristics of the three main subatomic particles: protons, neutrons, and electrons? [9]

b) Discuss how electric potential and electric field strength are related. [4]

c) What are the fundamental differences between magnetic fields and electric fields, as well as between magnetic forces and electric forces, in terms of their origins, properties, and effects on charged particles and currents? [8]

d) A rod of length ***l*** as shown in figure 1,has a uniform positive charge per unit length **λ** and a total charge **Q**. Calculate the electric field at a point **P** that is located along the **x** axis of the rod and a distance **a** from the rod. [8]

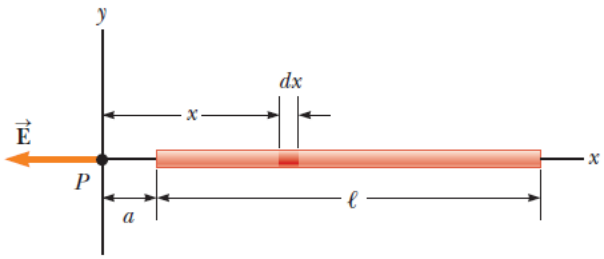

Figure 1: The electric field at P due to a uniformly charged rod lying along the x axis.

e) Show that the ideal power equation of a transformer is given by $\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$ where V_s is the voltage in the secondary coil, V_p is the voltage in the primary coil, I_p is the current in the primary coil, I_s is the current in the secondary coil, N_s is the number of turns of the secondary coil and N_p is the number of turns of the primary coil. [5]

f) State and explain

(i) Faraday's law of induction [3]

(ii) Lenz law [3]

SECTION B

QUESTION 2

(a) Distinguish between electric potential and potential difference. [4]

(b) Calculate the V_{rms} and the I_{rms} values for a system with a maximum Voltage and current of 100V and 5A respectively. [6]

(c) An insulating solid sphere of radius **a** has a uniform volume charge density **ρ** and carries a total positive charge **Q**, using Gauss law

(i) Calculate the magnitude of the electric field at a point outside the sphere. [5]

(ii) Calculate the magnitude of the electric field at a point inside the sphere. [5]

QUESTION 3

(a) Give the following Maxwell's equations and state their scientific meaning.

(i) Gauss's law. [5]

(ii) Gauss's law in Magnetism. [5]

(iii) Faraday's law of Induction. [5]

(iv) Ampere – Maxwell law. [5]

QUESTION 4

(a) Define magnetic flux. [3]

(b) With aid of a diagram describe the following terms

(i) Mutual inductance. [5]

(ii) Self inductance. [5]

(c) Charges $\boldsymbol{q_1}$and $\boldsymbol{q_2}$ are located on the **x** axis at distances at distances **a** and **b** respectively from the origin as shown in figure 2 below. Find the components of the net electric field at a point **P**, which is at position (0, y). [7]

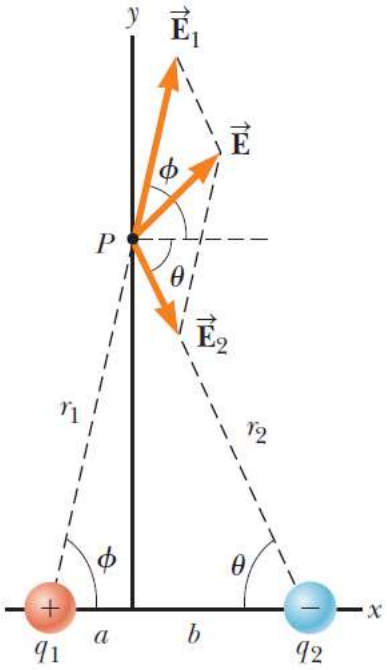

Figure 2: Diagram showing the electric field **E** at a point P.

QUESTION 5

(a) State Ohm's law and give any one use of a resistor in a circuit. [3]

(b) Define capacitance (C) of a capacitor. [2]

(c) Two conductors of the same material and length have different resistances. Conductor A is a solid 1.00mm in diameter wire. Conductor B is a tube of inner diameter 1.00mm and outer diameter 2.00mm. Find the ratio of the resistance of conductor A to conductor B.[5]

(d) Derive the equation for capacitors in:

(i) Parallel. [5]

(ii) Series. [5]