FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

ELECTRICITY AND MAGNETISM

EGS 1210

Final Examination Paper

September 2023

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**
6.	**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 $m_p = 1.67 \times 10^{-27}\ kg$

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SECTION A

QUESTION 1

a) What is an electric field? On a well labelled diagram draw electric field lines of a positive charge, negative charge and a dipole. [8]

b) Distinguish between an Ohmic and a Non Ohmic material. [4]

c) 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]

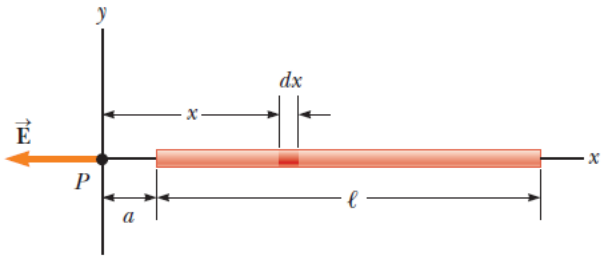

Figure 1: The electric field at P due to a uniformly charged rod lying along the x axis.

d) 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. [6]

e) The voltage output of an AC source is given by the expression $\Delta v = 200 \sin \omega t$, where Δv is in volts. Find the rms current in the circuit when this source is connected to a 100-V resistor. [5]

f) Define the following terms

(i) Paramagnetism [3]

(ii) Diamagnetism [3]

(iii) Ferromagnetism [3]

SECTION B

QUESTION 2

(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]

QUESTION 3

(a) Define the electric flux. [2]

(b) 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. [8]

(iii) Sketch the electric field **E** versus radius **r** of the Gaussian surface. [5]

QUESTION 4

(a) What is an inductor? What is it used for in an electric circuit? [4]

(b) Using Amperes law, derive the equation for the magnetic field **B** around a long current carrying conductor. [6]

(c) Derive the equation $I_{avg} = nqAv_d$ for the average current in a conductor where I_{avg} is the average current, *n* is the number of mobile charge carriers per unit volume, *q* is the charge on each carrier, *A* is cross-sectional area of cylindrical conductor and v_d is the velocity of the carriers. [6]

(d) State and explain the Biot-Savart rule. [4]

QUESTION 5

(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 6

(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).

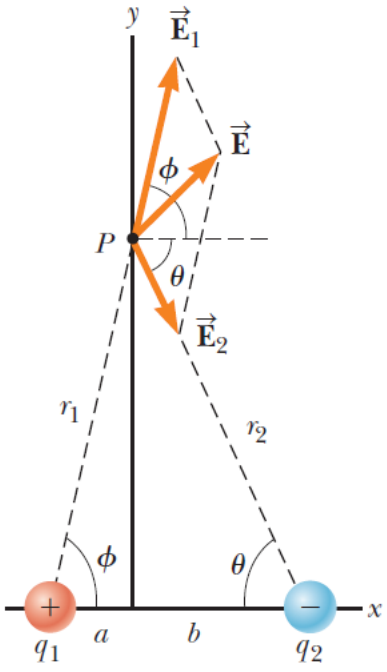

Figure 2: Diagram showing the electric field **E** at a point P.