



FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

ELECTRICITY AND MAGNETISM

ESG 1210

Final Examination Paper

April 2024

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 $\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

Charge of an electron $e = 1.6 \times 10^{-19} \text{ C}$

Mass of an electron $m_e = 9.11 \times 10^{-31} \text{ kg}$

Mass of a proton $m_p = 1.67 \times 10^{-27} \text{ kg}$

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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]

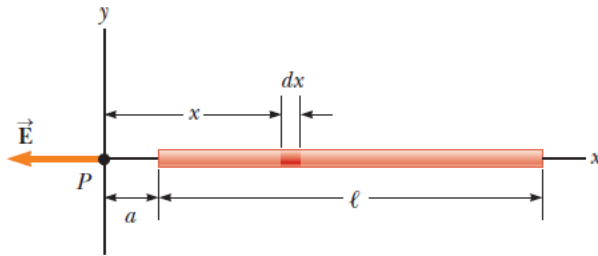


Figure 1: The electric field at P due to a uniformly charged rod lying along the x axis.

- 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 100Ω 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 q_1 and q_2 are located on the x axis 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]

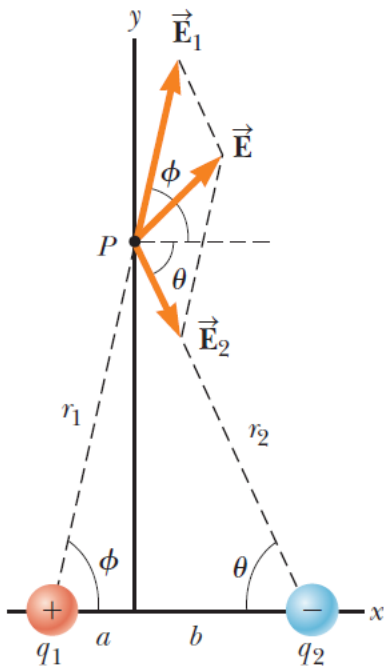


Figure 2: Diagram showing the electric field E at a point P .

