



KISII UNIVERSITY
UNIVERSITY EXAMINATIONS
SPECIAL EXAMINATION
THIRD YEAR EXAMINATION FOR THE AWARD OF THE DEGREE OF
BACHELOR OF EDUCATION (SCIENCE)
FIRST SEMESTER 2021/2022
(JULY, 2022)

PHY 312: ELECTROMAGNETISM II

STREAM: Y3 S1

TIME: 2 HOURS

DAY: TUESDAY, 3:00 PM – 5:00 PM

DATE: 26/07/2022

INSTRUCTIONS:

- 1. Do not write anything on this question paper.**
- 2. Answer Question ONE (Compulsory) and any other TWO questions.**

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{F/m}$,
 Permeability of free space $\mu_0 = 4\pi \times 10^{-7} \text{T- m/A}$

QUESTION ONE (30 MARKS)

- a) Define the term Gaussian Surface as used in relation to electric and magnetic fields (1 mark)
- b) State the Divergence theorem and cite an area in which this tool finds wide application (2 marks)
- c) One of the following electrostatic fields is impossible. Which one?
 (i) $E(\mathbf{r}) = k [xy \hat{x} + 2yz \hat{y} + 3xz \hat{z}]$
 (ii) $E(\mathbf{r}) = k [y^2 \hat{x} + (2xy+z^2) \hat{y} + 2yz \hat{z}]$ (6 marks)
- d) Obtain an equation for the magnetic field B if the wire in which current is flowing is long enough and B is tangential everywhere. (3 marks)
- e) A wire segment 3mm long carries current of 3A in the direction of x and lies in a magnetic field of 0.02T in the xy plane making an angle of 30° with the x-axis. What is the magnetic force exerted on the wire segment? (3 marks)

- f) Find the electric field a distance z above the midpoint of a straight line segment of length $2L$ which carries a uniform line charge λ . (6 marks)
- g) Given two infinite straight line charges λ a distance d apart moving along at a constant speed v .
- What would be the value of v that would have a magnetic attraction balance the electrical repulsion? (6 marks)
 - Calculate the numerical value of v . (3 marks)

QUESTION TWO

- i) The magnitude of a position vector $r = \sqrt{(x^2 + y^2 + z^2)}$.
- Find the gradient of the quantity given. (3 marks)
 - What is represented by the value obtained in i(a) above (3 marks)
- ii) Two vectors $A = 2\hat{i} + 3\hat{j} - 4\hat{k}$ and $B = \hat{i} - 2\hat{j} + \hat{k}$. Obtain
- The dot product $A \cdot B$ (3 marks)
 - The magnitude of the scalar product $|A||B|$ (3 marks)
 - The angle between the two vectors, θ . (3 marks)
 - The vector product $A \times B$ (3 marks)
 - The magnitude of the vector product $|A \times B|$ (3 marks)

QUESTION THREE

- i) One source of magnetic fields is a permanent magnet. List two other sources. (2 marks)
- ii) Explain one characteristic of magnetic fields. (1 mark)
- iii) State Lorentz Force Law (1 mark)
- iii) Two current carrying conductors are placed a distance d apart parallel to each other. Using Lorentz Force Law, show that force between the two conductors is given by:

$$f = \frac{\mu_0 I_1 I_2}{2\pi d}$$

(4 marks)

- iv) A long straight wire is carrying a steady current I .
- Find the magnetic field a distance z from the wire. (6 marks)
 - The wire was then made into a circular loop of radius R . Obtain the magnetic field a distance z above the centre of the circular loop. (6 marks)

QUESTION FOUR

- i) Define the following terms as used in electrostatics: (2 marks)
(a) Capacitor
(b) Dielectric
- ii) Briefly explain how temperature affects the alignment of dipole moments of a dielectric. (2 marks)
- iii) The inner and outer cylinder conductors of a long coaxial cable used to transmit TV signal have a diameter $a = 0.5\text{mm}$ and $b = 1.5\text{mm}$. What is the capacitance per unit length of this cable? (4 marks)
- iv) A parallel plate capacitor has square plates of sides 10cm separated by 1mm .
- a) Calculate its capacitance (3 marks)
- b) If this capacitor is charged to 12V , how much charge is transferred from one plate to the other? (3 marks)
- c) If the capacitor is filled with a dielectric of constant $k = 2$
- (i) Find the new capacitance (3 marks)
- (ii) Find the charge on the capacitor with the dielectric if the capacitor is connected to a 12V battery. (3 marks)

QUESTION FIVE

- i) State Biot-Savart's law (1 mark)
- ii) Show that the force due to a magnetic field B that results from a current carrying conductor is given by:
- $$\vec{F} = I \vec{L} \times \vec{B} \quad (6 \text{ marks})$$
- iii) A point charge of magnitude $q = 4.5 \text{ nC}$ is moving with a velocity of $3.6 \times 10^7 \text{ m/s}$ parallel to the x -axis along the line $y = 3\text{m}$. Find the magnetic field produced by this charge when the charge is at point where $x = -4\text{m}$ and $y = 3\text{m}$. (10 marks)
- iv) The magnetic field of any point in a region around a current has been found to depend on three factors. List the three factors. (3 marks)