KIBABII UNIVERSITY

FIRST SEMESTER UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

SECOND YEAR REGULAR EXAMINATIONS
FOR THE DEGREE
OF
BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **SPH 217**

COURSE TITLE: **ELECTRICITY AND MAGNETISM**

DATE: 01/02/2022 **TIME: 2-4PM**

INSTRUCTIONS TO CANDIDATES: Answer question ONE (COMPULSORY) and any other TWO questions

Answer question ONE and any TWO of the remaining

Symbols used bear the usual meaning.

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

a. Two point charges +5μC are placed 5cm apart. Calculate the electric potential and the electric field at the midpoint of the line joining the charges. (3.Marks)

b. A parallel plate capacitor has plates of area 5 x10^{-5} m^2, separation 1mm and charge 10nC. Calculate the change in energy stored by the capacitor when a dielectric of relative permittivity 2.5 replaces the air between the plates of the capacitor.(2.Marks).

c. Three point charges each of +16C are placed at the corners of an equilateral triangle with sides of length 2cm. Calculate the potential energy of the system measured with respect to a zero when the three charges are on an infinite distance apart. (4.Marks)

d. Define; Surface charge density, Volume charge density, Electrostatics, Torque (4.Marks)

e. The electric dipole shown below consists of two point charges –Q and +Q separated by distance S.

Show that when r>>>S, the electric potential V at point P is given approximately by

$$V = \frac{PCos\theta}{4\pi\varepsilon r^2}$$

(6.Marks)

When P = QS is the moment of the dipole, hence show that the radial E_r and angular E_θ components of E-field due to a dipole one is given by

$$E_r = \frac{2pCos\theta}{4\pi\varepsilon r^3} \quad \text{and} \quad E_\theta = \frac{PSin\theta}{4\pi\varepsilon r^3}$$

A dipole moment has a moment of 2 x 10^{-9} cm, calculate

i. The potential
ii. The radial component of the electric field
iii. The angular component of the electric field
iv. The total electric field
v. Show that the total E-field has a magnitude given by

$$E = \frac{P\left(1+3Cos^2\theta\right)^{1/2}}{4\pi\varepsilon r^e}$$ (7.Marks)

This Paper Consists of 3 Printed Pages. Please Turn Over.

f. A parallel plate capacitor has circular plates of 8.2 cm radius separated by 1.3mm of air. They are connected to a 240V power supply and allowed to charge up before being disconnected.

i. Calculate the capacitance of the capacitor

ii. What charge will appear on the plates?

iii. What is the electrical potential energy stored between the plates

(4marks)

QUESTION TWO

a. Two particles, each having a mass of 5g and charge 1.0×10^{-7} C, stays in limiting equilibrium on a horizontal table with a separation of 10cm between them. The coefficient of friction between each particle and the table is the sme. Find the value of the coefficient. (6marks)

b. Find the electric field at a point **P** on the perpendicular bisector of a uniformly charged rod. The length of the rod is L, the charge on it is **Q** and the distance of **P** from the centre of the rod is **a.** (7marks)

c. Given Gauss's law in the integral form, $\int_s \mathbf{E}.d\mathbf{S} = \sum \frac{Q}{\varepsilon_o}$, derive the differential form $\nabla.\mathbf{E} = \frac{\rho}{\varepsilon_o}$. $\mathbf{E}$ is the electric field vector and d$\mathbf{S}$ a vector specifying an element of ε_0 the closed surface S. Q is the charge and ρ is the charge density. The equations are valid for a vacuum where the relative permittivity $\varepsilon_r = 1$ (4marks)

d. A circular coil of radius 1.5cm carries a current of 1.5A. If the coil has 25 turns, find the magnetic field at the centre. (3marks)

QUESTION THREE

a) Two charges 10μC and -10μC are placed at points A and B separated by 10cm. find the electric field at a point P on the perpendicular bisector of AB at a distance of 12 cm from its middle point. (3marks)

b) A ring of radius **a** contains a charge **q** distributed uniformly over its length. Find the electric field at a point on the axis of the ring at a distance x from the Centre. (3marks)

c) Two charges +10uC and -20uC are placed are placed at a separation of 2cm. Find the electric potential due to the point at the middle of the line joining the two charges. (3marks)

d) What is meant by magnetic scalar potential (1mark)

e) The electric field in a region is given by $\vec{E} = (A/x^3)\vec{i}$ write a suitable SI unit for A. write also an expression for the potential in the region assuming the potential at infinite to be zero (4marks)

f) Discuss three quantities that characterize the earth's magnetic field at a point on its surface. (6marks)

QUESTION FOUR

a) State Lenz's law of electromagnetic induction. (1mark)

b) Highlight three ways of changing the magnetic flux in a loop put in a magnetic field. (3marks)

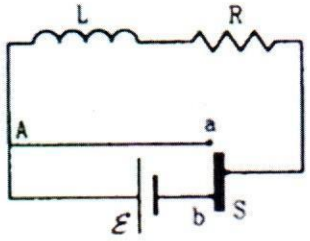
c) State the boundary conditions for (i) **E**-field and (ii) **D**-field at the interface between two dielectrics in the absence of any surface charge. (1 mark)

d) Is it possible to produce a magnetic field of the form $\mathbf{B} = x\mathbf{i}+y\mathbf{j}-z\mathbf{k}$? (2 marks)

e) Calculate the B - field a distance of 1 mm from a long straight wire carrying a current of 5A. (2 marks)

f) State the relationship between relative permeability and magnetic susceptibility- (2 mark)

g) The figure below shows an inductor connected to a battery and a resistor R. The sliding switch S can be slid up and down. A steady current $i = i_o$ is maintained through the circuit. If at $t = 0$ the switch connects to point a. Show that the current i decreases with time to 37% of the initial value in one time constant after the battery is disconnected. (4.marks)



h) A long solenoid of radius r and length l has n turns per unit length. A current i is passed through the solenoid. If the magnetic field inside the solenoid is $B = \mu_o ni$.Derive the expression of magnetic energy stored in the coil. (5marks)

QUESTION FIVE

a) The instantaneous value of an alternating current is given by $i = i_o \sin(\omega t + \varphi)$. Show that the value of the root mean square current is given by $i_{rms} = \frac{i_o}{\sqrt{2}}$ (7marks)

b) The peak value of an alternating current is $5A$ and its frequency is $60Hz$.
   i) Find its rms value (3marks)
   ii) How long will the current take to reach the peak value starting from zero.(2marks)

c) An emf $\in = \in_o \sin \omega t$ is applied in a circuit giving a current $i = i_o \sin(\omega t + \varphi)$. Derive the expression of the power delivered by the source. (5marks)

d) The electric field in an electromagnetic wave is given by $E = (50N/C)\sin\omega(t - {}^{x}/_{c})$. Find the average energy contained in a cylinder of cross section $10cm^2$ and length 50cm along the $x - axis$. (3marks)