(18)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.SC (PHYSICS)

COURSE CODE: SPC 322

COURSE TITLE: ELECTROMAGNETISM

DURATION: 2 HOURS

DATE: 23/11/2022 **TIME: 8:00AM-10:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- The following constants might be used: $K_e=9.0\times10^9$ N.m^2/C^2; $M_e=9.1\times10^{-31}$ kg; $M_p=1.6\times10^{-27}$ kg; $e=1.60\times10^{-19}$ C

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE [30 Marks]

a) State Gauss's law. [2]

b) A disk of radius 0.10 m is oriented with its normal unit vector $\hat{n}$ at 30^0 to a uniform electric fi $\vec{E}$ of magnitude $2.0\text{x}10^3$ N/C. What is the electric flux through the disk? [4]

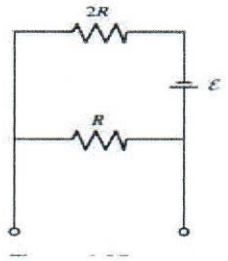
c) What is the meaning of "potential energy of a system of charges"? [2]

d) Prove for a conducting sphere with radius R and total charge q, the charge density of the sphere given as $E = \frac{\sigma}{\varepsilon_0}$. [4]

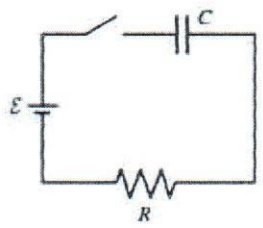
e) Show that electric potential of two point charges q and q_0 is given by $U = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r}$ when q_0 brought from infinity to r. [3]

f) State Thevenin theorem. [1]

g) Find the Thevenin equivalent ε_{eq} and R_{eq} for the circuit shown. [4]



h) A battery is connected to an RC circuit as shown. The switch is initially open, and the charge the capacitor is initially zero. If the switch is closed at t=0, find the charge on the capacitor a function of tir [4]



i) Give the Faraday's law of Induction. [2]

j) The distance between the two protons in helium nucleus could be at one instant as much as 10^{-15} How large is the force of electrical repulsion between two protons at the distance? [4]

QUESTION TWO [20 Marks]

a) A sphere has radius R and uniform charge density ρ. Find the potential for all values of r, both inside and outside the sphere. Take the reference point P1 to be infinitely far away. Draw a plot of $\phi(r)$ for the whole distance. [12]

b) The electric field equals the negative gradient of the potential, i.e. $\vec{E} = -\nabla\phi$. Show that $\nabla \times \vec{E} = 0$. [4]

c) A charge 2q is at the origin, and a charge –q is at x=a on the x-axis. Find the point on x-axis where the electric field is zero. [4]

QUESTION THREE [20 Marks]

a) Give an expression for Biot-savart law. [2]

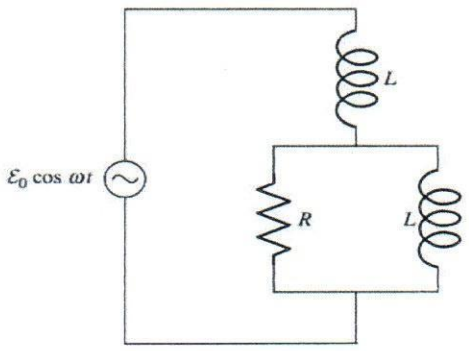
b) Prove that the vector potential $\vec{A}$ for a long straight wire carrying a current I is given

$$\vec{A} = -\hat{Z}\frac{\mu_0 I}{2\pi}\ln r\,.$$ [5]

c) Use Biot-savart law to calculate the field at a distance b from an infinite straight wire carrying current I. [13]

QUESTION FOUR [20 Marks]

a) The circuit shown has two equal inductors L and a resistance R. The frequency of emf source, $\varepsilon_0 \cos\omega t$, is chosen to be $\omega = \frac{R}{L}$.



i. What is the total complex impedance of the circuit? Give it in terms of R only. [4]

ii. If the total current through the circuit is written as $I_0 \cos(\omega t + \phi)$, what are I_o and ϕ_0? [4]

iii. What is the average power dissipated in the circuit? [4]

b) State Kirchhoff's junction rule. [1]

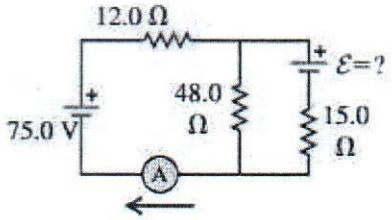
c) Show that the equivalent resistance for resistors in a parallel circuit is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$ [4]

d) A 10-MΩ resistor is connected in series with a 1.0 μF capacitor and a battery with emf 12.0 V. Before the switch is closed at a time t=0, the capacitor is uncharged. What is the time constant? [3]

QUESTION FIVE [20 Marks]

a) In the circuit shown, both batteries have insignificant internal resistance and the idealized ammeter reads 1.50 A in the direction shown. Find the emf ε of the battery. [6]



b) Write down the complete set of Maxwell's equations. [4]

c) State the three properties of electromagnetic waves. [3]

d) A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35T magnetic field perpendicular to the velocity of the proton. Find the linear speed of the proton. [3]

e) Define electric field at a point in space. [2]

f) What is capacitance of a capacitor? [2]

.....END.....