KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.SC (PHYSICS)

COURSE CODE: SPC 322

COURSE TITLE: ELECTROMAGNETISM

DURATION: 2 HOURS

DATE: 06/09/2022 **TIME:** 2:00PM-4:00PM

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

QUESTION ONE [30 Marks]

a) State Coulombs law. [2]

b) The distance between the two protons in helium nucleus could be at one instant as much as 10^{-15} m. How large is the force of electrical repulsion between two protons at the distance? [3]

c) A point charge q=-8.0 nC is located at the origin. Find the electric field vector at the field point x=1.2 m, y=-1.6 m. [4]

d) Define electric potential, ϕ_{12} and give its SI unit. [2]

e) Two protons and two electrons are located at corners of a rectangle with side a and b. there are two essentially different arrangement. Calculate the work required to assemble the system. [4]

f) Electric charge is distributed uniformly a long an infinitely long, thin wire. Assuming the charge per unit length λ, find the electric field using Gauss's law. [4]

g) Find the potential at a distance r from a very long line of charge with linear charge density (charge per unit length) λ. [4]

h) Define capacitance. [2]

i) The parallel plates of a 1.0 F capacitor are 1.00 mm apart. What is their area? [2]

j) Write an expression for Ampere's law. [1]

k) A copper wire L=1 km long is connected across a V=6V battery. The resistivity of copper is $\rho = 1.7 \times 10^{-8}$m, and the number of electrons per cubic meter is $N = 8.0 \times 10^{28}$ m^{-3}. What is the drift velocity of the conduction electrons under these circumstances? [2]

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]

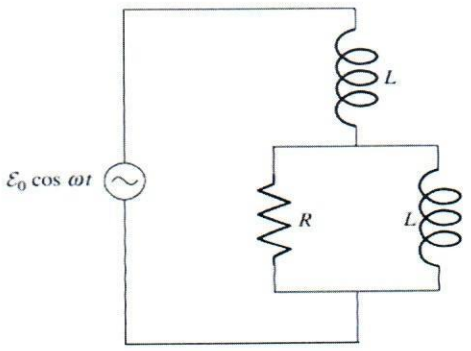
b) Prove that the vector potential $\vec{A}$ for a long straight wire carrying a current I is given

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

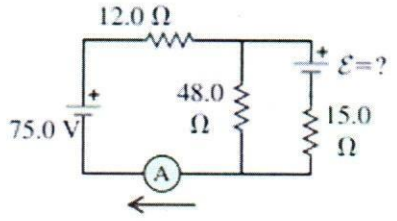
c) Show that the equivalent resistance for resistors in a parallel circuit is given by

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

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