KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE)

COURSE CODE: SPH 221

COURSE TITLE: ELECTRICITY AND MAGNETISM

DATE: 8/10/2021 **TIME:** 2:00-4:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

QUESTION ONE (30 marks) (COMPULSORY)

(a) State Coulomb's law and write down its equation (2mks)

(b) Consider a point, P, at a distance, x, along the perpendicular axis of the of the dipole $\vec{P}$ due to two charges +Q and –Q, a distance, d apart. Show that the electric field $\vec{E}$ due to dipole along x-axis is given by:

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{P}}{[x^2 + (\frac{d}{2})^2]^{\frac{3}{2}}}$$ (6mks)

(c) Given a hemisphere of radius, R having electric field $\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{-2Q}{r^2}\hat{r}$ on its surface, show that the electric flux through the surface is $\Phi = \frac{-Q}{\varepsilon_0}$. The symbols carry the usual meaning. (5mks)

(d) Show that $E_s = \frac{-dV}{ds}$ where E_s is the E-field component along the path $\Delta\vec{s}$ (8mks)

(e) Show that the capacitance of a parallel-plate capacitor is given by:

$$C = \frac{\varepsilon_0 A}{d}$$

where C is the capacitance of the parallel-plate capacitor, ε_o is permittivity of free space and d is the distance of separation between the plates (5mks)

(f) Consider a U-shaped conductor in a magnetic field, B. A sliding rod is placed on the conductor so that it rolls due to the force produced due to interaction between the two magnetic fields. Show that the power, P, required to keep the rod moving is given by:

$$P = I\frac{d(BA)}{dt}$$

where A is the area of the enclosed circuit. (4mks)

QUESTION TWO (20 marks)

(a) State any three conditions for validity of Coulomb's law (3mks)

(b) Consider a uniform line of charge density, λ at a distance, x, from a point P. If the uniform line has a length, L, show that the electric field, $E_x = \frac{\lambda}{2\pi\varepsilon_0 x}$ where L>>x (12mks)

(c) What is the electric force between two charges, q_1 = 50 Nano Coulombs and q_2 = 50 Nano Coulombs located 5cm apart (5mks)

QUESTION THREE (20 marks)

(a) State Gauss' law (1mk)

(b) Show that the electric flux of charge q over closed spherical surface of radius, R is:

$$\Phi_E = \frac{Q}{\varepsilon_0}$$

where ε_0 is the permittivity of free space (8mks)

(c) Consider an ink particle of mass, m, carrying charge, Q (Q < 0). Assuming that the mass of the ink drop is small, determine its vertical (y) deflection (5mks)

(d) Given a uniformly-charged ring with charge density, λ. By considering a point, P, at a distance, z, from the Centre of the ring, show that the electric potential exists between them and is given by:

$$V = \frac{Q}{4\pi\varepsilon_0|z|}$$ (6mks)

QUESTION FOUR (20 marks)

(a) Define the term electric current. (1mk)

(b) For a conductor of length, L, and cross-sectional area, A, carrying current, I, proof that the resistance offered to current flow through the conductor is given by:

$$R = \rho\frac{L}{A}$$

where ρ is the resistivity of the conductor (4mks)

(c) Obtain the expression for inductance for a toroid given that current, I, flows through it and the radius of the toroid is r. (6mks)

(d) Consider an infinitely long solenoid of cross-sectional area, A. Show that the energy per unit volume inside the inductor is given by:

$$u_B = \frac{B^2}{2\mu_0}$$ (7mks)

(e) Define the term resonance and give a practical example of a resonating system. (2mks)

QUESTION FIVE (20 marks)

(a) State any two applications of capacitors in our daily lives (2mks)

(b) Consider two concentric cylindrical wire of inner and outer radii, r_1, and r_2, respectively and length, L, such that $r_1 < r_2 << L$. By applying Gauss' law, show that the capacitance, C, of the cylindrical capacitor is given by:

$$C = 2\pi\varepsilon_0 \frac{L}{\ln \frac{r_2}{r_1}}$$ (7mks)

(c) Derive the Gauss' law in dielectric. (8mks)

(d) Given three resistors R_1, R_2 and R_3 in series, show that the effective resistance:

$$R_{eff} = R_1 + R_2 + R_3$$ (3mks)