CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE (PHYSICS)

PHYS 941: CLASSICAL ELECTRODYNAMICS

STREAMS: PhD (PHYSIC) Y1S1 **TIME: 3 HOURS**

DAY/DATE: THURSDAY 06/12/2018 **2.30 P.M – 5.30 P.M**

INSTRUCTIONS

- **Answer any four questions**

Useful constants: $\mu_o = 4\pi \times 10^{-7}$ H/m), $\varepsilon_o = 8.854 \times 10^{-12}$ F.m^{-1}, electronic charge = 1.6×10^{-19} C

Question one (15 marks)

(a) With an expression discuss the Coulomb's law and explain the factors that determines its magnitudes. (3 marks)

(b) Three identical equal charges, $q_1 = q_2 = q_3 = \mathbf{Q}$ are placed at the apex of an equilateral triangle of side **y**. Calculate the resultant force on a single charge at the apex of the triangle. (9mks)

(c) What's the force on a 0.1C charge moving at velocity v = (10j -20k) ms^{-1} in a magnetic field B = (3i+ 4k) x 10^{-4} Teslas. (3mks)

Question two (15 marks)

(a) Discuss Biot- Savert law using an expression and explain its parameters. (3mks)

(b) Using Biot- Savert law, show that the expression for magnetic flux due to a circular current loop of radius **R** at a point **P**, a distance **x** from the centre of current loop is given by;

$$B = \frac{\mu_0 IR^2}{2(R^2 + x^2)^{3/2}}$$

where **B** is the magnetic flux, **x** is the distance from the wire at which magnetic field is to be determined while μ_o is the permeability of free space (10mks)

(c) In 2 (b), determine the magnetic field when **x** >> **R** and when **x = 0** (2mks)

Question three (15 marks)

(a) Write a differential equation that a Green function $G'(x;x')$ for Poisson's equation must

satisfy, for Dirichlet boundary conditions. Include a statement of the boundary conditions. (5mks)

(b) A problem has Dirichlet boundary conditions. Derived the general solution to the Poisson equation for electrostatic potential $\phi(x)$ using a Green's function? (5mks)

(c) In an electrostatics problem with Neumann boundary conditions, what is the simplest allowable boundary condition on the Green's function $G'(x;x')$? Hint: The result must be consistent with the differential equation that G satisfies. (5mks)

Question four (15 marks)

(a) At the upper surface of the Earth's atmosphere, the time average magnitude of the Poynting vector $\langle S \rangle = 1.35 \times 10^3 \text{ W/m}^2$ that is the solar constant.

(i) Assuming that the Sun's electromagnetic radiation is a plane sinusoidal wave, what are the magnitudes of the electric and magnetic fields? (5mks)

(ii) What is the total time-averaged power radiated by the Sun if the mean Sun-Earth distance $R = 1.5 \times 10^{11} \text{ m}$ Is (3mks)

(b) Compute the intensity of the standing electromagnetic wave given by;

$E_y(x, t) = 2E_0 \cos(kx) \cos(wt)$ and $E_y(x, t) = 2E_0 \cos(kx) \cos(wt)$ (7mks)

Question five (15 marks)

(a) An electric dipole with $q_1 = 20\ \mu C$ at (- d , 0) and $q_2 = -10\ \mu C$ at (+ d , 0) is in a two dimensional Cartesian coordinate. Calculate the resultant electric field strength at a point with coordinates (x,y). Take d =1 m and x =y= 2 m. (7mks)

(b) Discuss the four Maxwell's equation of classical electromagnetism with a source (8mks)