CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE IN PHYSICS

PHYS 841: ELECTRODYNAMICS

STREAMS: MSC (PHYS) YISI **TIME: 3 HOURS**

DAY/DATE: TUESDAY 10/12/2019 **2.30 PM – 5.30 PM**

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) Two parallel wires carry currents of 8A and 2A in the same direction are shown in figure 1.1.

(i) What is the magnitude of the magnetic field midway between the wires? (5 marks)

(ii) What is the direction of the net magnetic field? (1 mark)

(iii) Where between the two wires is the magnetic field zero? (4 marks)

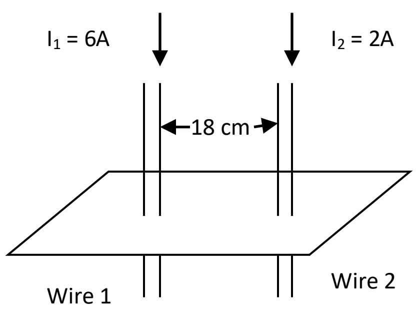

Figure 1.1. Two parallel wire carrying currents of different magnitude.

(b) A particle of mass m is rotating in a cyclotrone of radius R and experiencing a magnetic field of magnitude B. If the particle has a charge q, show that the period of rotation

T is given by; $$T = \frac{2\pi m}{qB}$$ (3 marks)

(c) Discuss Biot- Savert law using an expression and explain its parameters. (2 marks)

Question two (15 marks)

(a) Using Amperes law, show that the expression for magnetic flux due to a long wire at a single point, a distance **y** from the wire is given by;

$$B = \frac{\mu_0 I}{2\pi y}$$

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 (10 marks)

(b) An electric dipole with q_1 = 20 µC at (- d , 0) and q_2 = -10 µC 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. (5 marks)

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. (5 marks)

(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? (5 marks)

(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. (5 marks)

Question four (15 marks)

(a) Discuss the four Maxwell's equation of classical electromagnetism with a source. (6 marks)

(b) A group of three equal charges, **Q** are placed at the corners of an equilateral triangle of side **x**. Show that the resultant force on the charge at the top of the apex of the triangle is given by;

$$F = \frac{Q^2\sqrt{3}}{4\pi\varepsilon_0 x^2}$$

(9 marks)

where **Q** is the charge placed at each apex of the triangle, **x** is the length of the side of the triangle.

Question five (15 marks)

(a) 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. (3 marks).

(b) Show that the expression for magnetic flux due to a circular current loop of radius **R** at a point **Q**, a distance **d** from the centre of the current loop is given by;

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

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

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