University of Louisville
College of Arts and Sciences

Department of Physics and Astronomy PhD Qualifying Examination (Part I)

Spring 2016

Paper B – Electromagnetism

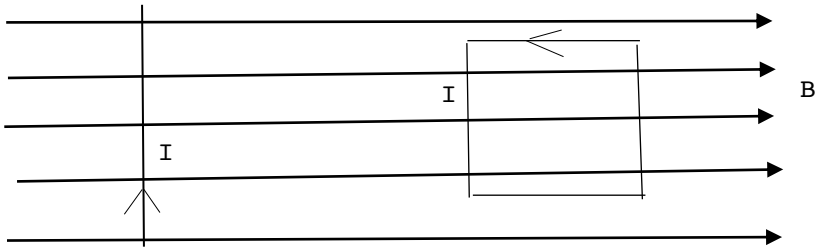
Time allowed – 90 minutes

Instructions and Information:

- Answer both questions
- This is a closed book examination
- Start each question on a new sheet of paper – use only one side of each sheet
- Write your identification number on the upper right hand corner of each answer sheet
- You may use a non programmable calculator
- Partial credit will be awarded.
- Correct answers without adequate explanations will not receive full credit.
- Make sure your work is legible and clear
- The points assigned to each part of each question is clearly indicated

E&M Basic

A long straight wire carrying a current of 3 A is in a region of space with a uniform **B** field magnitude 2 T as indicated in (i) below.



(a) Determine the force per unit length on the wire – magnitude and direction. Ignore the effect of the loop (ii) on the straight current. (8)

A square loop of wire, side 2 cm, carrying a current of 3 A is placed in the same magnetic field (as shown in (ii)). For parts (b) and (c) ignore the effect of the straight wire on the loop.

(b) Determine the magnitude and direction of the magnetic moment of the loop. (7)

(c) Calculate the magnitude and direction of the torque felt by the loop. (8)

(d) Write down the mathematical form of Ampere's Law in terms of a line integral of **B**. (4)

(e) Use this form of Ampere's Law to determine the expression for the **B** field due to a the long straight wire in terms of the distance "r" from the wire and the current in the wire, I. Specify exactly your assumptions about **B** based on the symmetry of the problem. Make sure you draw a diagram and indicate clearly the Amperian loop you have chosen and the direction of **B**. (8)

E&M Intermediate

Charge is distributed with constant surface charge density σ on a circular disc of radius a, lying in the xy plane with center at the origin.

(a) Sketch this arrangement and define the variables (**r**, **r′**, **R**, **da**) necessary to evaluate the electric potential at a point on the z-axis. (10)

(b) Show that the electric (scalar) potential at a point on the z-axis is given by,

$$\phi = \frac{\sigma}{2\varepsilon_0}\left[(a^2 + z^2)^{1/2} - |z|\right]$$

(28)

(c) Evaluate the electric field at the same point on the z axis. (17)

(d) How much work is necessary to bring a point charge +q from infinity to a point on the z-axis, distant 5a from the disc ? (10)