University of Louisville
College of Arts and Sciences

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

Spring 2013

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 copper rod 2 m in length has a square cross section with 1 mm sides and carries a uniform current of 5 A.

(a) What is the current density in the rod ? (4)

(b) Given the resistivity of copper is 1.5×10^{-8} Ω.m, what is the magnitude of the electric field inside the rod ? (4)

(c) Determine the potential difference between the ends of the rod. (4)

(d) What is the resistance of the rod ? (4)

(e) Determine the electrical power dissipation in the rod. (4)

(f) Calculate the drift velocity of the conduction electrons in copper [number of electrons per cubic meter in copper = 10^{28}, use e = 1.5×10^{-19} C for the charge on the electron]. (6)

(g) Evaluate the magnetic force on the rod when it is placed perpendicular to a 0.5 T uniform magnetic field. (9)

E&M Intermediate

(a) Using the Biot-Savart law, obtain the expression for the **B** field on the z axis, a distance z from the origin, due to a circular loop of current (I), radius a, in the xy plane, with its centre at the origin. (25)

(b) Two such circular loops with the same radius, carrying the same current in the same sense, have their centers on the z axis separated by a distance s, with their planes parallel to the xy plane. Assuming one loop's centre coincides with the origin as in part (a) above, obtain an expression for the **B** field, on axis, at an arbitrary point between the loops. (10)

(c) Show that $\partial B/\partial z = 0$ midway between the loops. (10)

(d) Show that when s = a, $\partial^2 B/\partial z^2 = 0$ midway between the loops. For this value of s the loops constitute a Helmholtz coil. (10)

(e) Under this condition (s = a) obtain an expression for the **B** field midway between the loops ? (10)