Electromagnetism (PHYS 295): Week 9

Spring 2024 v1.0

Intro:

This week we'll finish our discussion of the the Biot-Savart law for the B-field, likely derive the expression relativistic energy, and discuss the "$I\ell \times B$" force. We may also complete the relativistic transformations of the E and B fields.

Due in class, 10 AM Friday, April 12

Reading:

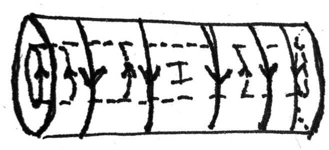
- PM Chapter 6 pages 298 - 306 (We will skip 6.3 on the vector potential. Section 6.7 is on the transformation of the fields.

A look ahead:

- Electromagnetic induction - Chapter 7

Problems:

(1) Two long solenoids are made by winding wires around two cylinders. One has n_1 turns per unit length and a radius of a. The second has n_1 turns per unit length and a radius of b with $b > a$. Each solenoid carries a current I but in opposite directions. Find the B-field in the three regions inside, between the cylinders, and outside. Here's a rough sketch



with the current flowing down on the outer cylinder and up on the inner one.

(2) In class I defined the current density $\mathbf{J}$ to be

$$I_{encl} = \int_S \mathbf{J} \cdot d\mathbf{a}$$

for the surface S bounded by the loop C that defines the line integral in Amperé's law $\oint_C \mathbf{B} \cdot d\mathbf{s}$. But, which surface S? You can image blowing out the surface like a balloon ... there are infinitely many surfaces bounded by the loop C. Which surface are we to use? Explain.

(3) 6.31 Adding B-fields from different wires

(4) 6.34 Feel free to use the method discussed in the problem or what we (will do in class)

(5) 6.37 Use superposition!

(6) 6.50 B-field of a paperclip

(7) 6.51 Estimates for he source of the Earth's field

(8) 6.55 The famous Helmholtz coils, examples of which lie in Gordon's lab.

(9) 6.62 Designing solenoids. In a previous experiment that Gordon and Brian worked on, aCORN, they required a uniform field to a part in 10^5.