

Electromagnetic Theory: Homework 18

Due: 1 November 2019

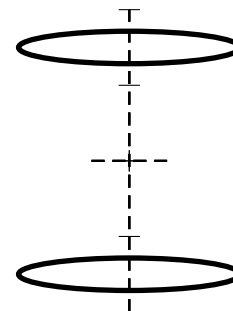
1 Magnetic field produced by currents

The text uses the Biot-Savart law to determine the magnetic field produced by a straight current of finite length. Use this to determine the field in the following situations.

- a) A square with sides of length L carries current I . Determine the magnetic field at the center of the square.
- b) An equilateral triangle with sides of length L carries current I . Determine the magnetic field at the center of the triangle.

2 Helmholtz coil

A Helmholtz coil consists of two circular loops with radius R separated by distance d as illustrated. Each carries a constant current circling in the same direction. They are arranged so that the origin is at the midpoint between them.



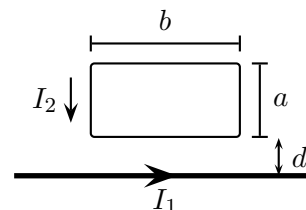
- a) Determine an expression for the magnetic field at any point along the vertical axis.
- b) We would like the field to be as uniform as possible at the midpoint between the loops. Determine conditions so that

$$\frac{\partial B}{\partial z} = 0 \quad \text{and} \quad \frac{\partial^2 B}{\partial z^2} = 0.$$

- c) For the conditions that produce the greatest uniformity, determine the field at the midpoint between the loops.

3 Force exerted by a straight wire on a loop

A loop with the illustrated dimensions is situated near an infinitely long wire. They carry the indicated currents. Determine the net force exerted by the straight wire on the loop.



4 Griffiths, *Introduction to Electrodynamics*, 4ed, 5.41, page 256. A classic physics problem and experiment! This is what lets us determine the signs of charges that flow in a wire.

5 Ampère's law and cylindrical currents

An infinitely long cylinder, whose axis is along the z axis, contains a current described by current density $\mathbf{J}(\mathbf{r}') = J_z \hat{\mathbf{z}}$.

- a) If J_z only depends on s' can you use Ampère's law to easily calculate the magnetic field produced by the current? Explain your answer.
- b) If J_z only depends on ϕ' can you use Ampère's law to easily calculate the magnetic field produced by the current? Explain your answer.
- c) If J_z only depends on ϕ' can you use the field produced by an infinite straight wire calculate the magnetic field produced by the current in the cylinder? Explain your answer.