# Electromagnetic Theory: Homework 18

Due: 27 October 2020

## 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 the 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.
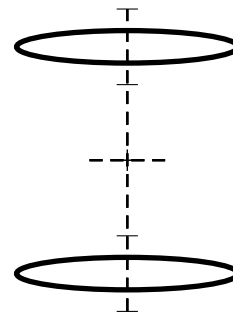
 a) Determine an expression for the magnetic field at any point along the vertical axis.

 b) We would like the field to be as uniform as possible at the midpoint between the loops. Determine conditions so that

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

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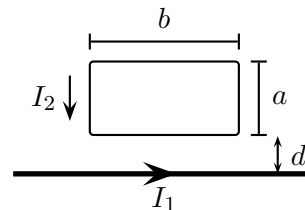
**4** Griffiths, *Introduction to Electrodynamics, 4ed*, 5.41, page 256. A classic physics problem and experiment! This is what lets us determine the signs of charges that flow in a wire.

## 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 $\phi'$ 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 $\phi'$ 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.