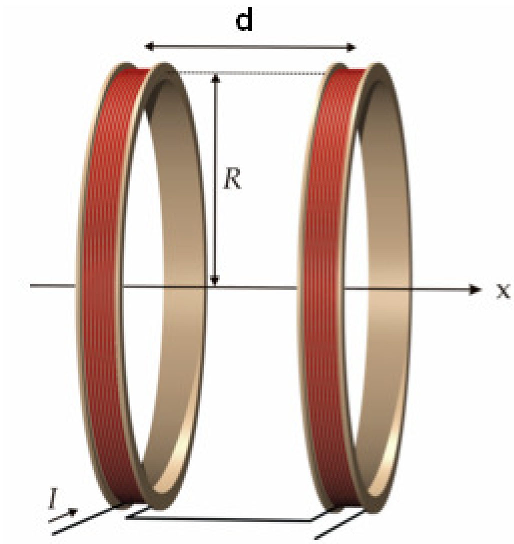
Homework #2 (due 02/06)

Boas Chapter 1

1.15; 10.24; 13.14; 13.29 (*please give first 4 terms of the series*); 15.3; 15.14; 15.28; 16.11; 16.17 (*please give first 4 terms of the series*); 16.22;

Extra-credit problem – Helmholtz coils



Consider a pair of two identical circular magnetic coils of radius **R** that are placed symmetrically one on each side of the experimental area along a common axis **x**, and separated by the distance **d**. Each coil carries an equal electrical current **I** flowing in the same direction. (*Note: for all the calculations in this problem consider points only along* x-*axis.*)

1) Start with the formula for the on-axis magnetic field due to a single wire loop (which is itself derived from the Biot-Savart law):

$$B = \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$$

Where:

μ_0= the permeability constant = $4\pi \times 10^{-7} Tm/A = 1.26 \times 10^{-6} Tm/A$

I= total coil current

R= coil radius

x= distance from the plane of the coil on axis.

Calculate the value of the magnetic field exactly between two coils.

2) Find the ratio between the radius of the coils **R** and the distance between the coils **d** which produces nearly spatially uniform magnetic field in the central region of the coils (Helmholtz configuration). To find this ratio consider a small on-axis displacement Δx from the central point, present the magnetic field as a power series of Δx. Then find the ratio between **R** and **d** which makes the first non-trivial term of the expansion zero. (*Hint: your answer should look very simple!*)

3) Use computer to plot on-axis magnetic field in the whole region between two coils, and estimate the length (in terms of coils' radius) of the central region with magnetic field changing *(a)* less that 1% and *(b)* less than 5%.