Introduction To Accelerator Physics Homework 3

Due date: Tuesday September 20, 2011

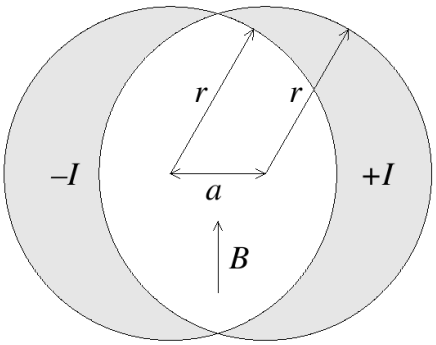
(Need help? Email satogata at jlab.org)

1 Reading

(0 points) Read section 2.5, "Weak focusing synchrotron", of Conte and MacKay.

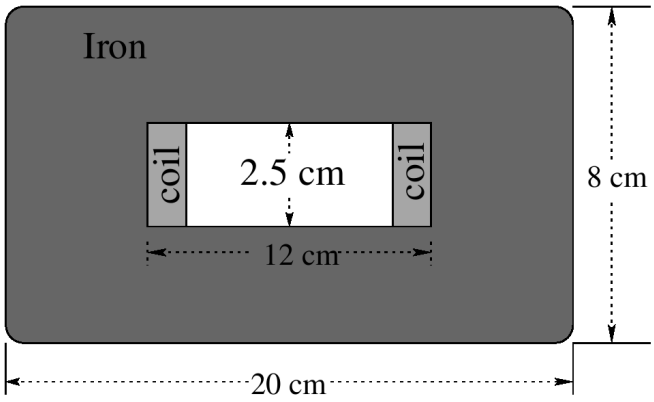
2 A Simple $\cos\theta$ Magnet (C&M 4–8)

(15 points) A magnet is constructed from conductors with a transverse cross section as shown in the figure. Show that there is a unform magnetic field in the intersection region of the two circles.



3 Designing A Window Frame Magnet (C&M 4–12)

Consider a 1m long window-frame dipole magnet with the cross section shown in the figure below.



(a) (4 points) Estimate the number of ampere-turns necessary to achieve a 0.6 T field in the gap. Assume that the iron is not saturated, so the relative permeability is roughly $\mu_r \equiv (\mu/\mu_0) = 5000$.

(b) (4 points) Air-cooled copper coils can carry as much as 1.5 A/mm^2, while water-cooled copper coils can carry almost 10 times as much current density. However water-cooling also adds the potential for water leaks and is more expensive, so it is not done unless necessary. For the given magnet dimensions, would you recommend water-cooled or air-cooled magnets? How much horizontal space would be available between the coils?

(c) (3 points) If the magnet is to be powered by a power supply with a maximum current of 1000 A, how many turns should be used in the coil?

(d) (3 points) What is the stored energy in the gap?

(e) (3 points) Assuming constant field in the iron, estimate the additional energy stored in the iron yoke.

(f) (3 points) Estimate the inductance of the magnet.