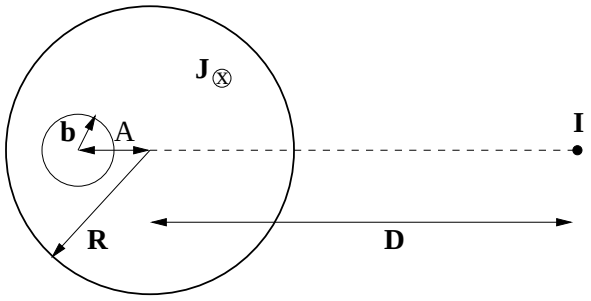
PHYS 4392
Fall 2014
TE Coan
Due: 14 Nov '14 6:00 PM

Homework 10

1. An infinitely long cylindrical conductor has an off-center cylindrical hole cut in it, as shown in the figure. The remaining portion of the conductor carries a uniform current density J into the plane of the paper. Find the force $\mathbf{F}$, including the direction, exerted on the conductor by a parallel current filament a distance D away carrying a current I in the direction out of the paper.



2. A cylindrical conductor of radius a carries a uniform current density of magnitude $\mathbf{J}$. Sketch or plot the magnitude of the magnetic field as a function of the distance s from the center of the conductor for values of s up to 5 times the conductor's radius. Gnuplot or Mathematica may come in handy.

3. (a) Find the current density J to float a copper wire in Earth's magnetic field. Assume the experiment is done at Earth's magnetic equator in a B-field of 10^{-4} Tesla. The mass density of Cu is $\rho = 8.9\,\mathrm{g/cm^3}$.

(b) Will the wire become hot? Explain one way or the other. The resistivity of Cu is 1.7×10^{-8} ohms-meter. You may have to review some PHYS 1304 material.

4. Find the magnetic dipole moment $\mathbf{m}$ of a disk of paper of radius R with charge Q uniformly spread over the surface spinning at angular velocity ω about the symmetry axis of the disk. Be sure to indicate the direction of $\mathbf{m}$.

5. The Zeeman effect (see your modern physics text) observed in the spectra of sunspots reveals the existence of magnetic fields as large as 0.4 Tesla. Assume that the magnetic field is due to a disk of electrons 10^7 meters in radius and rotating at an angular velocity $\omega = 3 \times 10^{-2}$ rads/sec. The thickness of the disk is small compared to its radius.

(a) Show that the number density η of electrons required to achieve a B-field of 0.4 Tesla is $\eta \simeq 10^{19}/\text{meter}^2$.

(b) Now show that the current $I \simeq 3 \times 10^{12}$ amperes.

(c) This part is a head banger. In view of the enormous size of the Coulomb forces, such charge densities are clearly impossible. How then could such currents exist? Hint: Think of electricity in a common household wire, even though the Sun contains no copper wiring.