MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Experimental Study Group

Physics 8.022, Spring 2011

Problem Set 8
Ampère's law, Biot-Savart law

Due: Sunday, April 3rd at 10 PM

Problem 1: Long flat conductor

A long flat conductor of width a carries a sheet of current i (see Figure 1). You are asked to find the magnetic field (direction and magnitude) near the center of its flat side and and very close to the surface, such that the distance R from the sheet is $R \ll a$.

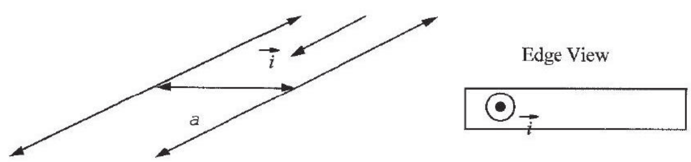
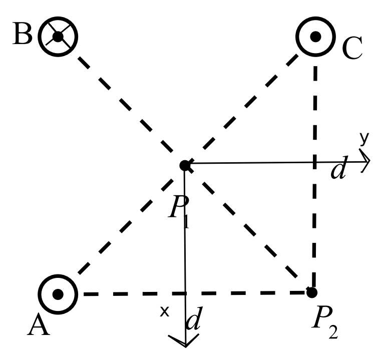


Figure 1: Flat conductor

Problem 2: Magnetic field of three wires — Purcell 6.5

Three long straight parallel wires are located as shown in the diagram. One wire (B) carries current $2I$ into the paper; each of the others (A and C) carries current I in the opposite direction. What is the strength if the magnetic field at P_1 and P_2?

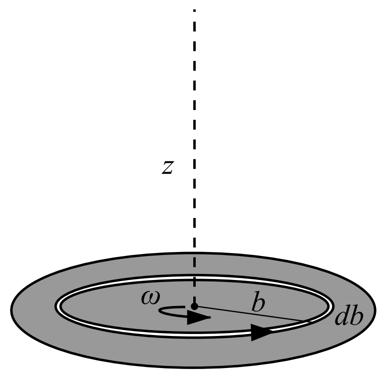


Problem 3: Bent wire revisited

In class we found the magnetic field at the center of a wire bent through 180°. Solve it instead for the wire bent through some arbitrary angle.

Problem 4: Magnetic field due to a spinning disk

A flat circular disk with radius R carries a uniform surface charge density σ. It rotates with an angular velocity ω about the z-axis. Find the magnetic field $\vec{B}(z)$ at any point z along the rotation axis.



Problem 5: Coaxial cable

A long coaxial cable consists of two concentric conductors, as shown in figure Figure 2 below. The inner conductor is a cylinder with radius a, and it carries a current I uniformly distributed over its cross section. The outer conductor is a cylindrical shell with inner radius b and outer radius c. It carries a current I that is also uniformly distributed over its cross section, and that is opposite in direction to the current of the inner conductor. Calculate the magnetic field $\vec{B}$ and plot the field strength as a function of the distance from the axis.

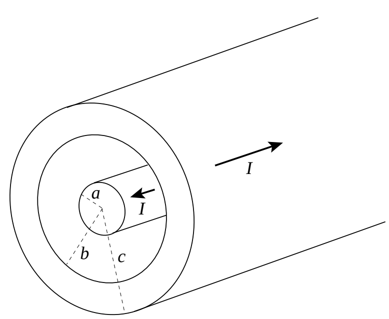


Figure 2: Cross-section of a long coaxial cable.

Problem 6: Toroidal Solenoid — Purcell 6.14

What is the magnetic field inside and outside of the solenoid in Figure 3?

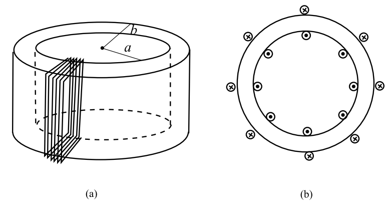


Figure 3: A Toroidal Solenoid

Problem 7: Vector potential of a solenoid

Find the vector potential $\vec{A}$ inside and outside of an infinite solenoid of radius R with n turns per centimeter, each carrying current I. Find the solution for $\vec{A}$ which is symmetric about the axis of the solenoid.
HINT: You can come up with a *very* simple way to compute $\vec{A}$ by putting together

- The magnetic flux, $\Phi_B = \int \vec{B} \cdot d\vec{a}$
- The definition $\vec{B} = \vec{\nabla} \times \vec{A}$
- Stoke's theorem.

Problem 8: The Director's Challenge — Extra credit!!!

Formulate an interesting problem that relates a topic from 8.022 to your intended major or any other topic about which you are passionate. Give references to help future students to understand the context. Try to give a solution. Any method — theoretical, analytical, numerical, experimental — is acceptable. If you can't give a full solution, outline partial solutions. Enjoy!