

Intro to magnetic fields and Ampere's law

Reading assignment

Paul, Whites, and Nasar, 4.2 -> 4.4 (emphasis on 4.4)

Software

div_curl_example.m

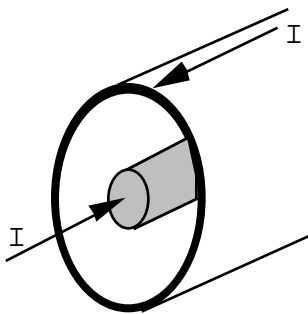
Problem 1 - Magnetic field properties

Run div_curl_example.m. Which of the fields shown are possible magnetic fields? Which are possible electrostatic fields?

Problem 2 - Symmetry

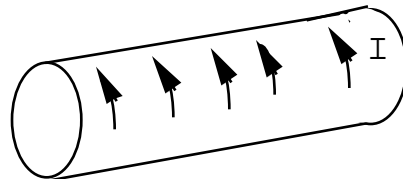
Three standard geometries for analytical magnetostatic calculations are shown below.

- Use the right hand rule (thumb along the current direction, fingers for \mathbf{B}) and determine the direction of \mathbf{B} in each case.
- All 3 geometries can best be analyzed in cylindrical coordinates. For each, determine whether \mathbf{B} is a function of r , θ , and/or z . (Example from electric fields, \mathbf{E} of cylindrically symmetric charge is only a function of r .)



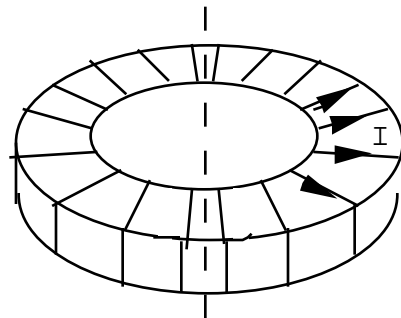
Coaxial cable

I is in z direction



Solenoid

I is in z direction



Toroid

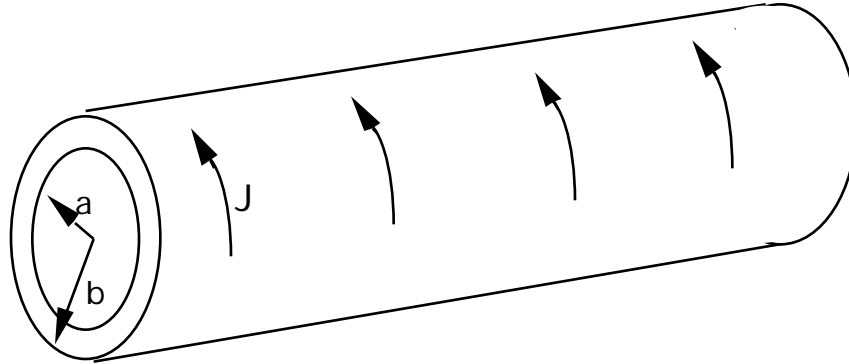
I wraps around core

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Problem 3 - Ampere's Law

A long solenoid has a current density of $\mathbf{J} = J_0 \mathbf{a}$ for $a < r < b$ and is 0 everywhere else. Ignore end effects.

- a. Find the magnetic flux density, \mathbf{B} for $r < a$. Be sure to sketch the line integral paths you use. Assume $\mathbf{B} = 0$ for $r > b$.



- b. Check your answer to part a. by evaluating $\nabla \cdot \mathbf{B}$ and $\nabla \times \mathbf{B}$.
- c. Find \mathbf{B} for $a < r < b$. Sketch the line integral path you use.
- d. Check your answer to part c. by evaluating $\nabla \cdot \mathbf{B}$ and $\nabla \times \mathbf{B}$.
- e. Plot B_z vs r .
- f. Show that $\mathbf{B} = 0$ for $r > b$.