NTNU

Dpt. of Electronics and Telecommunications,
IME faculty,
NTNU

TFE4120 Electromagnetics - Crash course

Exercise 4

Problem 1

A round wire with a radius a is conducting current in the $\mathbf{z}$-direction.

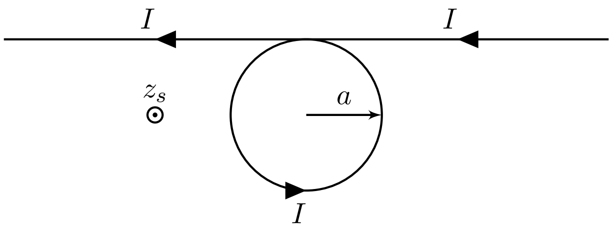
a) Find the current density $\mathbf{J}$ when a current I is evenly distributed across the cross section of the wire.

b) Find the total current I flowing in the conductor when the current density is given by

$$\mathbf{J} = \begin{cases} 2J_0 \frac{r^2}{a^2}\hat{\mathbf{z}}, & r \leq a \\ 0, & r > a. \end{cases} \tag{1}$$

Problem 2

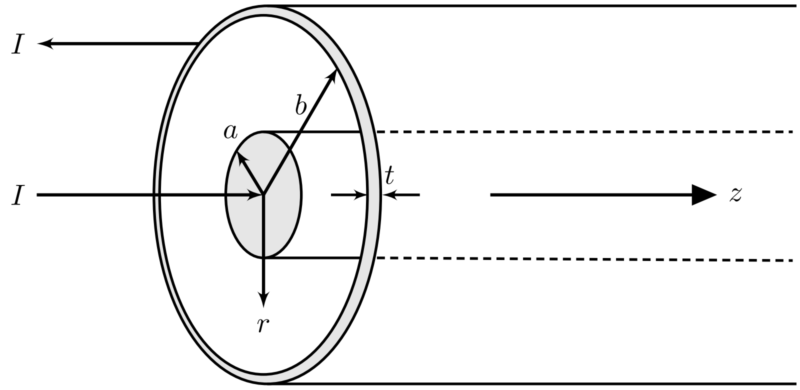
Imagine a long, straight and thin conductor. It is bent so that it creates a sircular loop with radius a. The conductor conducts the current I. Find an expression for the magnetic flux density $\mathbf{B}$ at the center of the loop.



Hint: We can solve this task using superposition and divide it in the following way: First calculate the field from the loop (by using Biot-Savart's expression for a line current), and secondly calculate the field from a straight conductor (or simply look it up in the lecture notes). Finally we add the contributions.

Problem 3

Imagine a coaxial cable where the radius on the inner conductor is a, the inner radius on the outer conductor is b and the thickness of the outer conductor is t.

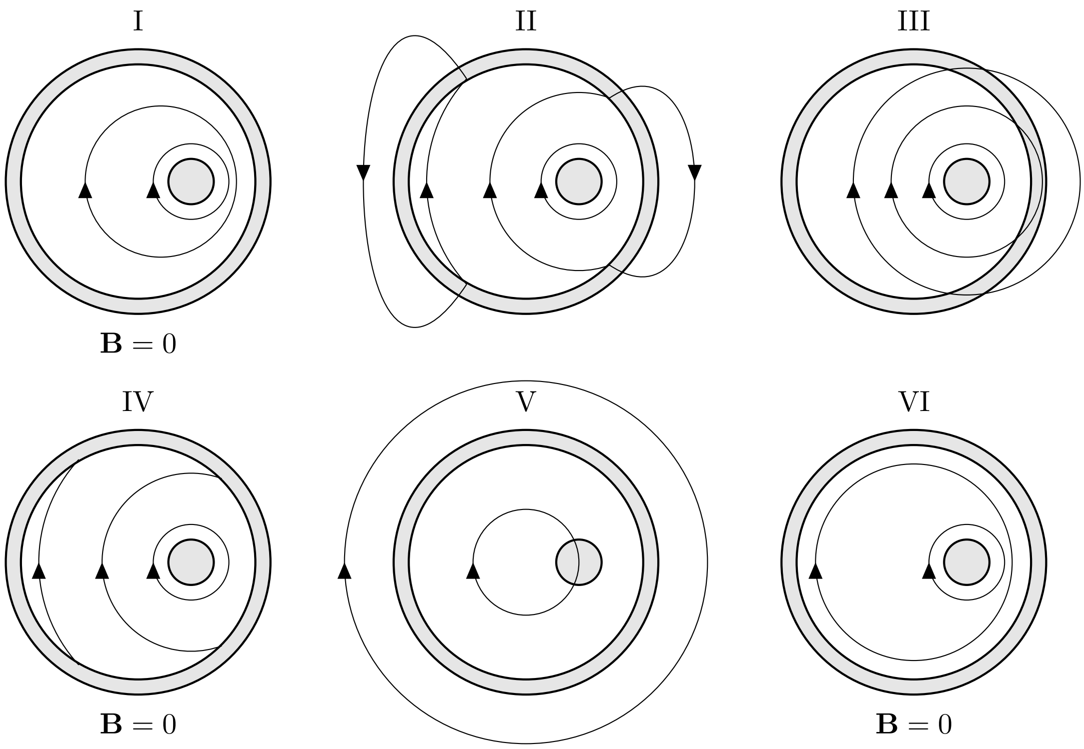


The current I is assumed to be evenly distributed across the inner conductor and the return current I is assumed to be evenly distributed across the outer conductor.

a) Calculate and sketch the magnetic field strength $|\mathbf{B}|$ as a function of r.

Hint: Use Ampère's law.

b) Assume that the conductors are shifted so that they no longer are concentric. The current is assumed to still be evenly distributed across the inner and outer conductor. The figure on the next page shows six proposals to the approximate magnetic flux density distribution. Which one of them is correct? Support your answer by showing that the remaining five sketches must be wrong.



Approximate magnetic flux density distributions for task **3b)**.

Problem 4

Given a long, tightly wound, solenoid with a total of N turns per length l. The windings conduct a current I. Find the magnetic flux density $\mathbf{B}$ inside the solenoid.

Hint: Assume (or argue that) $\mathbf{B} = 0$ outside the solenoid and use Ampères law.