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B03 Electrical Engineering
Electromagnetic field theory **2023 /2024**

Series 2

Magnetostatic Field

Exercise 1: Earth's magnetic field

A solenoid comprising N = 1000 contiguous turns has a length L = 80 cm. It carries a current of intensity I. a) Make a diagram in which you represent:

- the magnetic spectrum of the solenoid
- the North and South faces
- the magnetic field vector at the center of the solenoid.

We assume the solenoid is long enough to be comparable to a solenoid of infinite length.

b) What is the expression for the intensity of the magnetic field at the center of the solenoid?

A.N. Calculate B if I = 20 mA.

The axis of the solenoid is placed perpendicular to the plane of the magnetic meridian. In the center of the solenoid we place a small movable compass around a vertical axis.

c) What is the orientation of the compass for I = 0?

When the current of intensity I = 20 mA passes through the solenoid, the compass rotates by an angle $\alpha = 57.5°$.

Deduce the intensity Bh of the horizontal component of the earth's magnetic field.

Exercise 2: Magnetic field created by a turn

Using the Biot and Savart formula, determine the characteristics of the magnetic field created at the center of a flat coil of N turns, of radius R and carried by a current I. Numerical application: R = 5 cm, N = 100 and I = 100mA.

Exercise 3: Magnetic field created by a cable

We consider a cable of radius R, of infinite length, traversed by a current of intensity I evenly distributed in the conductor section. Using Ampère's theorem, determine the intensity of the magnetic field at a point located at the 3distance r from the axis of the cable. Draw the curve B(r).

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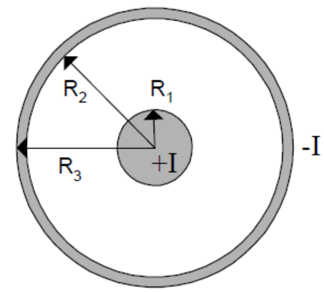
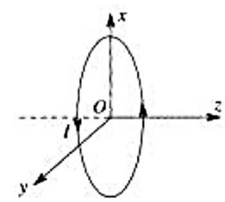
Exercise 4: Magnetic field created by a coaxial cable

We consider an infinite cylindrical coaxial cable of radii R1, R2 and R3. The current of total intensity I passes in one direction in the inner conductor and returns in the other direction through the outer conductor.



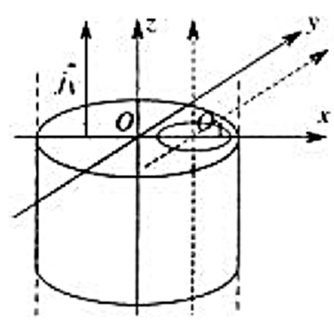
Exercise 5:

Turn carrying a filiform current of intensity I. Consider a turn of radius a and axis (Oz) traversed by a current of intensity I. What are the symmetries and invariances of this distribution?



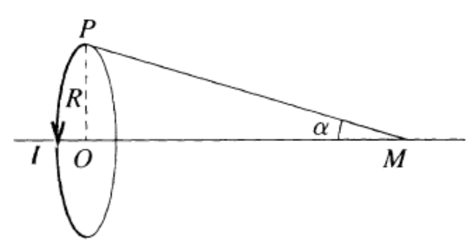
Exercise 6:

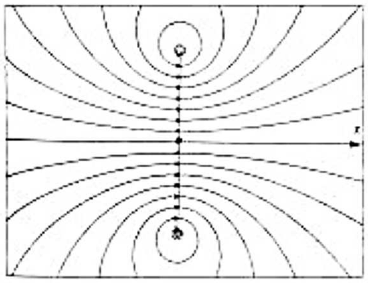
Cylinder with cavity carrying a volume density of currents. An infinite cylinder with a circular base is traversed by a uniform volume current parallel to its generators. In this cylinder there is a cylindrical cavity with a circular base and generators parallel to the previous cylinder. Study the symmetries and invariances of this current distribution.



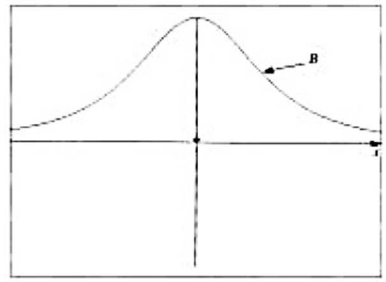
Exercise 7:

Field created by a circular turn on its axis. 1. Calculate the magnetostatic field created by a turn of radius R, traversed by a current of intensity I, at a point M of its axis (Ox), the turn being seen at angle a from M. 2. Interpret the following figures obtained with Maple:





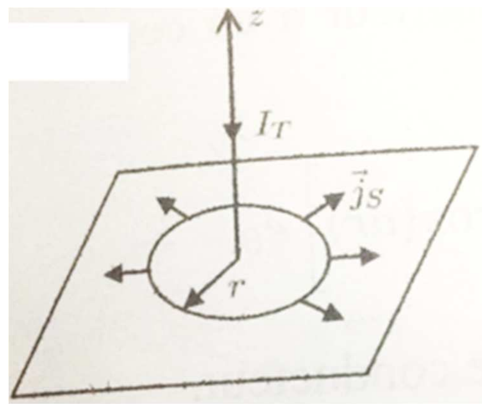
Lignes de champ magnétique d’une spire.



Champ sur l’axe d’une spire.

Exercise 8:

A current of intensity IT travels a filament along the z axis and penetrates a thin conductive layer at z=0. Express the surface current density vector js for this sheet.



Exercise 9:

Find the intensity of the current which passes through the surface of a sphere of radius r centered at the origin, knowing that the current density vector is given by:

$$j = I_0 \frac{\sin(\theta)}{r^2} e_r$$

Exercise 10:

In a cylindrical conductor with a radius of 2mm, the current density varies with the distance from the axis according to the relation $j = 10^3 e^{-400r} (Am^{-2})$. Find the total current intensity.

Exercise 11:

Calculate the magnetic field B in the region surrounding an infinitely long rectilinear wire-shaped current, of intensity I. Deduce the vector potential A.

Exercise 12: Using Ampere's theorem, calculate the magnetic field B created by a solid cylindrical conductor, of radius a, carried by a current of intensity I, uniformly distributed across the straight section.

Exercise 13:

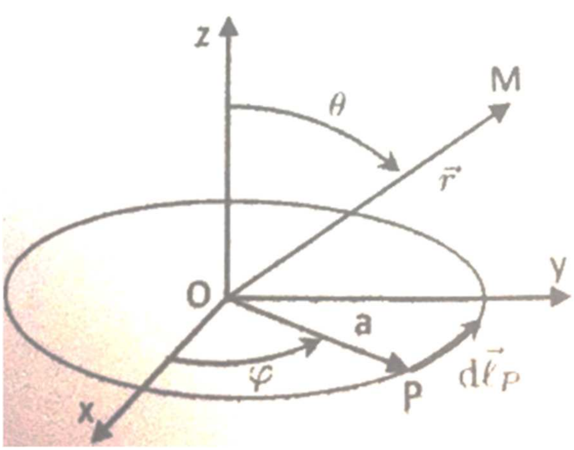
In a cylindrical coordinate system, the current density is:

$$j = \begin{cases} 4.5e^{-2r}\ (Am^{-2}) & 0 < r < 0.5m \\ 0 & partout\ ailleurs \end{cases}$$

- Find the magnetic field B by Ampère's theorem.

Exercise 14:

We have a circular turn with center O, radius a, axis (Oz), traversed by a current I. We want to calculate the magnetic field created at a point M at a long distance from the turn (i.e. OM>> a).



1. Calculate the vector potential dA created at point M by an element dlp of the turn located at a current point P.

2. Deduce the components of the vector potential A(M) created by this turn.

3. Deduce the components of the magnetic field B created by this turn.

4. Compare the form of these expressions with the expressions for the electric field created by an electrostatic dipole.