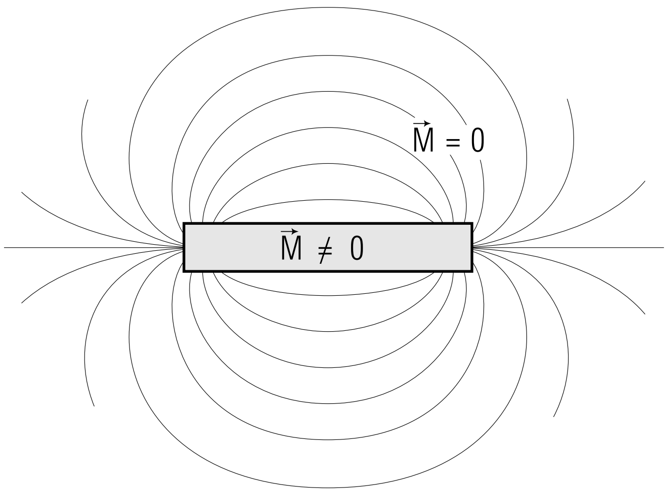
MISN-0-141

MAGNETIC FIELDS IN BULK MATTER: MAGNETS



Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

MAGNETIC FIELDS IN BULK MATTER: MAGNETS

by
J. S. Kovacs
Michigan State University

Title: **Magnetic Fields in Bulk Matter: Magnets**

Author: J. S. Kovacs, Michigan State University

Version: 2/1/2000 Evaluation: Stage B0

Length: 1 hr; 8 pages

Input Skills:

1. Vocabulary: magnetic dipole moment (MISN-0-130).
2. State Ampere's law and use it to determine the magnetic field at the center of a long solenoid (MISN-0-138).
3. State the relation between magnetic dipole moments and atomic current loops (MISN-0-130).

Output Skills (Knowledge):

K1. Vocabulary: ferromagnetism, magnetic domain, magnetic permeability, magnetic susceptibility, magnetization vector, magnetizing field vector.

K2. Explain the basic mechanisms that produce ferromagnetism, including how external magnetic fields affect domains.

K3. Starting from the definition of the magnetization vector, derive the expression that defines the magnetizing field vector.

K4. Show that Ampere's law applied to the magnetizing field vector results in the circulation of the magnetizing field vector being the free current, whereas the circulation of the magnetic field is both the free current and the effective magnetization current.

K5. Explain the physical effects that are responsible for the magnetization curve of ferromagnetic substances.

External Resources (Required):

1. M. Alonso and E. J. Finn, *Physics*, Addison-Wesley (1970). For access, see this module's *Local Guide*.

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OF PROJECT PHYSNET

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New authors, reviewers and field testers are welcome.

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1. Introduction

The presence of magnetic fields in and due to bulk matter is the topic of this module. Under steady-state conditions, with time-independent electric and magnetic fields present, Ampere's law relates the line integral of the magnetic field vector $\vec{B}$ around any closed circuital path to the net current threading that circuital path. Under idealized conditions, with, say, a current-carrying filament in a vacuum, the application of Ampere's law is straightforward. If, however, there is material mass in the region where the line integral of $\vec{B}$ is to be evaluated, then the atoms and molecules in the matter also may contribute to the current that threads the circuital path along which the line-integral of $\vec{B}$ is evaluated. It is apparent then, that the value of $\vec{B}$ at any point in space may be modified by the presence of matter in the vincinity. Magnets are an obvious example.

2. Suggested Procedure

- In AF[1] read Sections 19.15, 19.16, 19.17 and 19.18.
  Note that $\epsilon_0 \equiv 1/(4\pi k_e)$ and $\mu_0 \equiv 4\pi k_m$.
- Supplementally it is recommended that you read Sections 10.1, 10.7, and the qualitative aspects of section 10.8.
- Work Problem 1 in the Problem Supplement.

3. Comments

- Section 19.15 of AF contains the essentials of Output Skill K2.
- Sections 19.16 and 19.17 deal with Output Skills K3 and K4. Be prepared to explain (or prove, where appropriate):

[1] M. Alonso and E. J. Finn, *Physics*, Addison-Wesley (1970). For access, see this module's *Local Guide*.

1. How the effective magnetization current arises.
2. How $\vec{M}$ and $\vec{H}$ are defined,
3. How the effective magnetization current doesn't enter when you evaluate the circulation of $\vec{H}$.

- Section 19.18 is appropriate to Output Skill K5. You should be sure to:

1. Understand the definitions of magnetic susceptibility and permeability and explain the relation: $\vec{B} = \mu \vec{H}$.
2. Be able to explain the properties exhibited in Figure 19.44 for ferromagnetic materials.

Acknowledgments

Preparation of this module was supported in part by the National Science Foundation, Division of Science Education Development and Research, through Grant #SED 74-20088 to Michigan State University.

LOCAL GUIDE

The readings for this unit are on reserve for you in the Physics-Astronomy Library, Room 230 in the Physics-Astronomy Building. Ask for them as "The readings for CBI Unit 141." Do **not** ask for them by book title.

MODEL EXAM

1. See Output Skills K1-K5 in this module's *ID Sheet*. The actual exam may contain any number or combination of these skills.

Brief Answers:

1. See this module's *text*.