

# APPLICATIONS OF MAGNETISM

## I. INSTRUCTIONAL OBJECTIVES

Upon the completion of this project area the following objectives will be achieved:

The student is expected

- A. to demonstrate a thorough understanding of magnetic fields and their effect on moving charged particles.
- B. to demonstrate an understanding of the effect of magnetic fields on permanent magnets placed in a field.
- C. to determine the direction of a magnetic field in the vicinity of both current carrying wires and permanent magnets.
- D. to apply the Biot-Savart Law to determine the magnetic induction vector in the vicinity of a current carrying wire.
- E. to demonstrate an understanding of ampere and coulomb based on their effects in a magnetic field.
- F. to apply Ampere's Law to determine the magnetic induction vector in the vicinity of a current carrying wire.
- G. to demonstrate an understanding of magnetic induction vector in the vicinity of a current carrying wire.
- H. to apply Faraday's Law so as to determine the EMF generated by a current carrying wire as it moves through a magnetic field.
- I. to apply Lenz's Law to both self and mutual induction.
- J. to demonstrate an understanding of diamagnetic, paramagnetic and ferromagnetic effects in matter.

## II. PROJECT OUTLINE

- A. Magnetic Fields
  1. Definition of magnetic field
  2. Forces on particles in magnetic fields
    - a. Moving particles
    - b. Particles at rest
  3. Magnetic Flux Density — lines of force
  4. Effects of magnetic flux on current carrying wires
  5. Torque on a current carrying loop (electric motors]
  6. Magnetic fields produced by current flow
    - a. Biot-Savart Law
    - b. Straight conductor
      - i. Field near
      - ii. Force between two parallel wires
    - c. Current loop — Ampere's Law
    - d. Solenoid
  7. Force, work and motion of a straight conductor in a magnetic field
  8. Faraday's Law and EMP of a changing magnetic field — induction
  9. Lenz's Law, self and mutual induction
  10. Magnetism and matter
    - a. Magnetic susceptibility and permeability
    - b. Magnetization and magnetic moment
    - c. Para, dia and ferro magnetism
    - d. Magnetic domain theory
    - e. Magnetic Intensity
    - f. Hysteresis
  11. Terms - poles, spin, magnetic field, magnetic flux density, pole strength, magnetic moment, magnetic induction, current loop, cyclotron, magnetic bottle, Hall Effect, Biot—Savart Law, ampere, coulomb, Ampere's Law, solenoid, magnetization, dipole moment, permeability, magnetic flux, weber, gauss, displacement current, motional EM?, Lenz's Law, Faraday's Law, self inductance, mutual inductance, magnetic energy, magnetic intensity, susceptibility, diamagnetic, paramagnetic, ferromagnetic, Bohr magneton, magnetic domains, hysteresis

## III. RELATED STUDENT ACTIVITIES

While studying this topic the students will spend considerable time developing the concepts of magnetism as related to natural magnets, current carrying wires and in matter.

The lab activities will include:

- A. measuring the magnetic force on a moving charged particle
- B. measuring the magnetic force between two current carrying wires
- C. measuring the magnetic force between a current carrying wire and a permanent magnet
- D. measuring the magnetic field strength in the vicinity of various sources of magnetic energy
- E. measuring the torque produced on a current carrying loop
- F. designing and building a unique (although possibly useless] device operating on the principle of magnetism.

#### **IV. STUDENT EVALUATION PROCEDURES**

The students will be evaluated on this topic by their performance on:

- A. Topical content (20%) — Each student will be evaluated on his/her ability to demonstrate a knowledge and understanding of the content enumerated in the proficiencies through ongoing written and/or verbal reports. Each project member is expected to keep an ongoing diary.
- B. Creativity and originality (20%) — This property of the project may include some or all of the following:
  1. Does the choice of the final project demonstrate original/creative thought?
  2. Does the approach to the project demonstrate original/creative thought?
  3. Does the use of materials and/or equipment demonstrate original/ creative thought?
  4. Does the project involve the development of new equipment or the use of old equipment in ‘a new or innovative way’?
- C. Final product (20%) — the final product of the project will be evaluated on some or all of the following criteria:
  1. A specific construct which clearly and thoroughly demonstrates the concepts behind the final project. Particular attention will be paid to how well the project helps to meet the goals as stated in the proficiencies.
  2. Charts and/or graphs which explain, compare, contrast or illustrate the concepts behind the project.
  3. The quality of the workmanship of the final project. It is expected that the project\*s quality will be indicative of the time spent.
- D. Oral report (20%) — The oral report is expected to be given by the individual project group to students in the Science/Engineering program as well as to professionals in the scientific or engineering disciplines if possible. The oral report must include participation by ALL members of the individual project group, must be sufficient in length to clearly present the project and will be evaluated on the following criteria:
  1. Is the oral report well organized and does it demonstrate sufficient preparation?
  2. Does the report include a clear statement of the goal of the project?
  3. Does the oral report include a clear explanation of the theory behind the project?
  4. Does the report include a carefully planned demonstration/explanation of the final product?
  5. Does the report include an evaluation of the success/failure of the project to reach the stated goal?
  6. What future lines of research regarding this project are possible and desirable?
- E. Written report (20%) — Each member of the project group is expected to submit a written report on the entire project including each of the following:
  1. A clear statement of the goal of the project including the motivation behind the selection of the specific topic.
  2. A thorough analysis of the theory behind the project demonstrating significant research into the background of the topic including an online web search of the concepts incorporated into the final product.
  3. A clear description of the procedures used in the development of the project.
  4. This report is also expected, where appropriate, to include CAD drawings of the proposed designs.
  5. A thorough analysis of the final product and its relationship to the stated goals.
  6. A concluding statement regarding the success/failure of the project reach the stated goals with relevant recommendations regarding future projects of a similar nature.

#### **V. MATERIALS REQUIRED**

Laboratory Materials:

- Current balance kit
- Assorted permanent magnets
- Assorted solenoids
- Mass sets
- Appropriate EM? sources
- Switches and connecting wires
- Electron deflection tube apparatus

#### **VI. RESOURCE MATERIALS:**

Physics, by Paul M. Tipler (Worth Publishers), 1982.