TOPIC 4.4: ELECTROMAGNETISM

The student will be able to:

S3P-4-25: Describe and demonstrate the phenomenon of electromagnetism.

S3P-4-26: Diagram and describe qualitatively the magnetic field around a current-carrying wire.
Include: direction and intensity of the field

S3P-4-27: Diagram and describe qualitatively the magnetic field of a solenoid.
Include: direction and intensity of the field

S3P-4-28: Describe and demonstrate the function of an electromagnet.
Include: common applications of electromagnets

S3P-4-29: Perform a lab to demonstrate that $B \propto I$ for an electromagnetic field.

S3P-4-30: Describe the force on a current-carrying conductor in a magnetic field.
Include: $F_B = BIl \sin\theta$

S3P-4-31: Define the magnetic field quantitatively as a force per unit current element (i.e., $B = F_B/Il$, where Il is a current element).

S3P-4-32: Solve problems, using $F_B = BIl$.

General Learning Outcome Connection

Students will...

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

Specific Learning Outcome

S3P-4-25: Describe and demonstrate the phenomenon of electromagnetism.

Suggestions for Instruction

Notes to the Teacher

Today we use electromagnetism in just about every aspect of our lives that depends on electricity. Electromagnetism works on the principle that moving charges generate a magnetic field. This magnetic field is the same force that is demonstrated by permanent magnets.

The domain theory should be related to the motion of the electron.

Demonstration

Hans Christian Oersted's discovery of electromagnetism can be demonstrated by placing a compass near a current-carrying conductor. The magnetic field around the wire causes the compass to deflect. However, if we turn the current off, the compass returns to a north-south alignment.

Suspend a 0.5-m long x 0.05-m wide strip of aluminum foil between the poles of a magnet. Connect a low-voltage power source (0-3 A) to the ends of the foil. The force acting on the current-carrying aluminum will "levitate" the foil.

SKILLS AND ATTITUDES OUTCOME

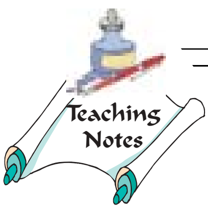
S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Evaluate, from a scientific perspective, information and ideas encountered during investigations and in daily life (GLO C8)

SPECIFIC LEARNING OUTCOMES

S3P-4-26: Diagram and describe qualitatively the magnetic field around a current-carrying wire.

Include: direction and intensity of the field

S3P-4-27: Diagram and describe qualitatively the magnetic field of a solenoid.

Include: direction and intensity of the field

S3P-4-28: Describe and demonstrate the function of an electromagnet.

Include: common applications of electromagnets

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

The magnetic field around a current-carrying wire forms concentric circles around the wire. The direction of the magnetic field is given by the "right-hand" rule: When the thumb of the right hand points in the direction of the conventional current, the fingers curl around the wire in the direction of the magnetic field.
Note: Some texts use a "left-hand" rule and the electron current.

If the wire is formed into a loop, the magnetic field around all parts of the wire contributes to the field in the middle of the loop, making it stronger. The magnetic field increases as we add more loops (solenoid). The field inside the solenoid is more intense, is constant, and is directed straight through the middle of the solenoid. The direction of the field is found by the "right-hand" rule. If the fingers curl in the direction of the conventional current, the thumb points in the direction of the field.

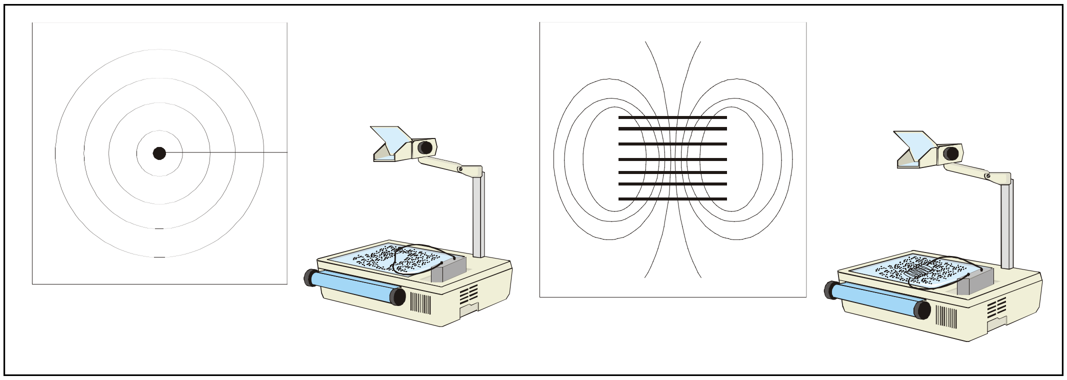
Teacher Demonstration

Various experiments and demonstrations can be used to describe the fields around a current-carrying wire. If the wire is wound through Plexiglas®, the fields can be displayed on the overhead.

The field of a solenoid can be intensified by placing an iron core inside the solenoid (i.e., an electromagnet). The permeability of an electromagnet describes how many times the field is intensified with the core.

Student Activities

Students can build a simple electromagnet.



SKILLS AND ATTITUDES OUTCOMES

S3P-0-3b: Describe examples of how technology has evolved in response to scientific advances, and how scientific knowledge has evolved as the result of new innovations in technology.

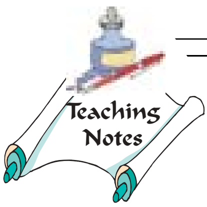
S3P-0-2b: Propose problems, state hypotheses, and plan, implement, adapt, or extend procedures to carry out an investigation where required.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

The concept of electromagnetism can also be combined with learning outcomes from the Waves topic to design, construct (or assemble), test, and demonstrate a technological device to produce, transmit, and/or control sound waves for a useful purpose.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOMES

S3P-4-29: Perform a lab to demonstrate that B ∝ I for an electromagnetic field.

S3P-4-30: Describe the force on a current-carrying conductor in a magnetic field.

Include: $F_B = BIl\sin\theta$

S3P-4-31: Define the magnetic field quantitatively as a force per unit current element (i.e., $B = F_B/Il$, where Il is a current element).

S3P-4-32: Solve problems, using $F_B = BIl$.

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

There are several labs that can be followed to achieve this learning outcome.

- The tangent galvanometer lab can be used to demonstrate the relationship between current and magnetic fields.
- The current balance can be used to find the relationship between F, B, I, and l for a wire and can be used to derive the field as a force per unit current element.

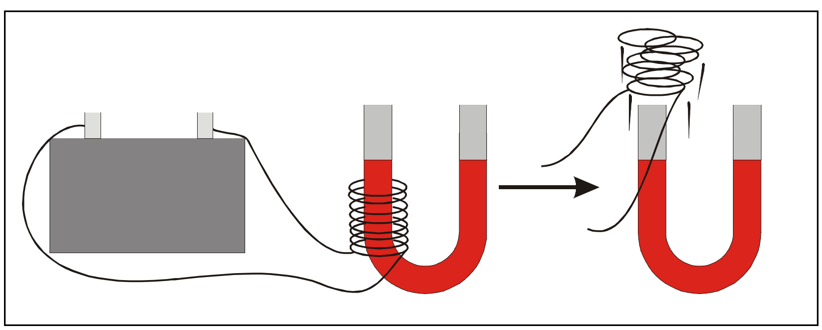
Student Activities

Using a digital scale, students place two opposite poles on the balance and zero the balance. Suspend a wire between the poles and connect to a power source. The magnetic force on the wire when a current is in the wire will be equal to the increase in scale reading times 9.8.

- Graph the relationship between force and current element (Il). The slope of the line is the magnetic field constant B.
- If the length of wire between the poles is increased (place two additional poles nearby), the force increases proportionally.

Teacher Demonstration

The Jumping Wire (HOT wire Caution!)



SKILLS AND ATTITUDES OUTCOMES

S3P-0-2e: Evaluate the relevance, reliability, and adequacy of data and data-collection methods.

Include: discrepancies in data and sources of error

S3P-0-2g: Interpret patterns and trends in data, and infer or calculate linear relationships among variables.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate appropriate critical thinking and decision-making skills when choosing a course of action based on scientific and technological information (GLO C4)

SUGGESTIONS FOR INSTRUCTION

SUGGESTIONS FOR ASSESSMENT

Journal Entries

Students diagram the field around a conductor, tangent galvanometer, current balance.

Performance Assessment

Ask students: If you were a mass (or positive/negative charge, or a magnet), describe how you would react to being:

- near the Earth (remember B_{earth})
- near a positive charge (which may or may not be moving)
- near a negative charge
- sandwiched between two plates
- near one pole of a magnet
- between two poles of a magnet
- inside a solenoid

SUGGESTED LEARNING RESOURCES

Herreman, W. and R. Huysentruyt. (1995) "Measuring the Magnetic Force on a Current Carrying Conductor." *The Physics Teacher* 33.5: 288.

NOTES