Unit 12: Magnetism

OBJECTIVES:
Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.
Enduring Understanding 1.E: Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.

Essential Knowledge 1.E.5: Matter has a property called magnetic permeability.

a. Free space has a constant value of the permeability that appears in physical relationships.

b. The permeability of matter has a value different from that of free space.

Essential Knowledge 1.E.6: Matter has a property called magnetic dipole moment.

a. Magnetic dipole moment is a fundamental source of magnetic behavior of matter and an intrinsic property of some fundamental particles such as the electron.

b. Permanent magnetism or induced magnetism of matter is a system property resulting from the alignment of magnetic dipole moments within the system.

Big Idea 2: Fields existing in space can be used to explain interactions.
Enduring Understanding 2.A: A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena.

Essential Knowledge 2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.

a. Vector fields are represented by field vectors indicating direction and magnitude.

b. When more than one source object with mass or electric charge is present, the field value can be determined by vector addition.

c. Conversely, a known vector field can be used to make inferences about the number, relative size, and location of sources.

Enduring Understanding 2.D: A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles.

Essential Knowledge 2.D.1: The magnetic field exerts a force on a moving electrically charged object. That magnetic force is perpendicular to the direction of velocity of the object and to the magnetic field and is proportional to the magnitude of the charge, the magnitude of the velocity, and the magnitude of the magnetic field. It also depends on the angle between the velocity and the magnetic field vectors. Treatment is quantitative for angles of 0°, 90°, or 180° and qualitative for other angles.

Learning Objective 2.D.1.1: The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field.

Essential Knowledge 2.D.2: The magnetic field vectors around a straight wire that carries electric current are tangent to concentric circles centered on that wire. The field has no component toward the current-carrying wire.

a. The magnitude of the magnetic field is proportional to the magnitude of the current in a long straight wire.

b. The magnitude of the field varies inversely with distance from the wire, and the direction of the field can be determined by a right-hand rule.

Learning Objective 2.D.2.1: The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires.

Essential Knowledge 2.D.3: A magnetic dipole placed in a magnetic field, such as the ones created by a magnet or the Earth, will tend to align with the magnetic field vector.

a. A simple magnetic dipole can be modeled by a current in a loop. The dipole is represented by a vector pointing through the loop in the direction of the field produced by the current as given by the right-hand rule.

b. A compass needle is a permanent magnetic dipole. Iron filings in a magnetic field become induced magnetic dipoles.

c. All magnets produce a magnetic field. Examples should include magnetic field pattern of a bar magnet as detected by iron filings or small compasses.

d. Earth has a magnetic field.

Learning Objective 2.D.3.1: The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet.

Essential Knowledge 2.D.4: Ferromagnetic materials contain magnetic domains that are themselves magnets.

a. Magnetic domains can be aligned by external magnetic fields or can spontaneously align.

b. Each magnetic domain has its own internal magnetic field, so there is no beginning or end to the magnetic field — it is a continuous loop.

c. If a bar magnet is broken in half, both halves are magnetic dipoles in themselves; there is no magnetic north pole found isolated from a south pole.

Learning Objective 2.D.4.1: The student is able to use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material.

Big Idea 3: The interactions of an object with other objects can be described by forces.
Enduring Understanding 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.

Essential Knowledge 3.C.3: A magnetic force results from the interaction of a moving charged object or a magnet with other moving charged objects or another magnet.

a. Magnetic dipoles have north and south polarity.

b. The magnetic dipole moment of an object has the tail of the magnetic dipole moment vector at the south end of the object and the head of the vector at the north end of the object.

c. In the presence of an external magnetic field, the magnetic dipole moment vector will align with the external magnetic field.

d. The force exerted on a moving charged object is perpendicular to both the magnetic field and the velocity of the charge and is described by a right-hand rule.

Learning Objective 3.C.3.1: The student is able to use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current- carrying conductor.

Learning Objective 3.C.3.2: The student is able to plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion.

Big Idea 4: Interactions between systems can result in changes in those systems.
Enduring Understanding 4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.

Essential Knowledge 4.E.1: The magnetic properties of some materials can be affected by magnetic fields at the system. Students should focus on the underlying concepts and not the use of the vocabulary.

a. Ferromagnetic materials can be permanently magnetized by an external field that causes the alignment of magnetic domains or atomic magnetic dipoles.

b. Paramagnetic materials interact weakly with an external magnetic field in that the magnetic dipole moments of the material do not remain aligned after the external field is removed.

c. All materials have the property of diamagnetism in that their electronic structure creates a (usually) weak alignment of the dipole moments of the material opposite to the external magnetic field.

Learning Objective 4.E.1.1: The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.

Essential Knowledge 4.E.2: Changing magnet flux induces an electric field that can establish an induced emf in a system.

a. Changing magnetic flux induces an emf in a system, with the magnitude of the induced emf equal to the rate of change in magnetic flux.

b. When the area of the surface being considered is constant, the induced emf is the area multiplied by the rate of change in the component of the magnetic field perpendicular to the surface.

c. When the magnetic field is constant, the induced emf is the magnetic field multiplied by the rate of change in area perpendicular to the magnetic field.

d. The conservation of energy determines the direction of the induced emf relative to the change in the magnetic flux.

Learning Objective 4.E.2.1: The student is able to construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux through an area defined by a current loop (i.e., a simple microphone or generator) or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area.

PROCEDURE:

I. Lesson 1: Magnetic Force on Moving Charges

- Roman Numerals I & II (A-C only)
- Develop and solve multiple practice problems
- Homework 1: Chapter 21 Conceptual Questions 2, 3, 5, 7, 11 and Problems 1 (The mass of a proton is 1.67 E-27 kg.), 2, 5a, and here are three challenges: #3 (Remember that moving through a potential difference changes a particle's energy. Then you can use the conservation of energy to find the particle's velocity.) #10 (You've got two fields. Remember the particle will move in the direction of the electric field (parallel to it.)) and #11 (Remember the magnetic force provides a centripetal force. You'll need to do circular kinematics for this problem.) I've given you these tougher problems because they are multi-concept problems that will help prepare you for a tougher FRQ. Hang in there!

II. Lesson 2: Magnetic Force on Current-Carrying Wires

- Roman Numeral II.D
- Develop and solve multiple practice problems
- Homework 2: Chapter 21 Problems 26, 27, 29, 30 (Don't give up on 30…You can definitely do it. Take it piece by piece…)

III. Lesson 3: Magnetic Fields Created by Current-Carrying Wires

- Roman Numeral III
- Develop and solve multiple practice problems
- Homework 3: Chapter 21 Conceptual Questions 13, 14 and Problems 47, 49

IV. Lesson 4: Electromagnetism

- Roman Numeral IV
- Develop and solve multiple practice problems
- Homework 4: Chapter 22 Conceptual Question 7 and Problems 1, 10, 17, 18, 28, 30