Introduction: Magnetism & Electromagnetism

Unit: Magnetism & Electromagnetism

Topics covered in this chapter:

This chapter discusses electricity and magnetism, how they behave, and how they relate to each other.

- *Magnetism* describes properties of magnets and what causes objects to be magnetic.
- *Magnetic Fields & Magnetic Flux* explains magnetic fields and magnetic flux and how it is calculated.
- *Electromagnetism* describes the relationship between electric fields and magnetic fields, and how changes in one induce changes in the other.
- *Devices that Use Electromagnetism* lists devices that combine electricity and magnetism and explains how they work.

One of the challenges encountered in this chapter is understanding which set of equations applies to a given situation.

Standards addressed in this chapter:

MA Curriculum Frameworks (2016):

HS-PS2-5. Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS3-5. Develop and use a model of magnetic or electric fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a magnetic or electric field, respectively.

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AP® Physics 2 Learning Objectives:

2.C.4.1: The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi-quantitative arguments based on vector addition of fields due to each point source, including identifying the locations and signs of sources from a vector diagram of the field. [**SP 2.2, 6.4, 7.2**]

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. [**SP 2.2**]

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. [**SP 1.1**]

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. [**SP 1.2**]

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. [**SP 1.4**]

3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [**SP 1.1**]

3.A.3.2: The student is able to challenge a claim that an object can exert a force on itself. [**SP 6.1**]

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3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force. [**SP 1.4**]

3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [**SP 1.4**, **6.2**]

3.A.4.2: The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [**SP 6.4**, **7.2**]

3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. [**SP 1.4**]

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. [**SP 1.4**]

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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. [**SP 4.2**, **5.1**]

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. [**SP 1.1**, **1.4**, **2.2**]

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. [**SP 6.4**]

Topics from this chapter assessed on the SAT Physics Subject Test:

- **Magnetism**, such as permanent magnets, fields caused by currents, particles in magnetic fields, Faraday's law, and Lenz's law.

1. Permanent Magnets
2. Magnetic Force on Charges
3. Magnetic Force on Current-Carrying Wires
4. The Magnetic Field Due to a current
5. Motional EMF
6. Faraday's Law

Skills learned & applied in this chapter:

- Working with material-specific constants from a table.

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