**KEY CONCEPTS:** electric field, magnetic field, electromagnetic force, electromagnetic induction, amperes

## NEXT GENERATION SCIENCE STANDARDS (NGSS)

### MIDDLE SCHOOL:

1. **MS-PS2-3:** Students who demonstrate understanding can ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
2. **MS-PS2-4:** Students who demonstrate understanding can conduct an investigation and evaluate the design of a device that minimizes or maximizes electric forces.
3. **MS-PS2-5:** Students who demonstrate understanding can conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
4. **MS-PS3-2:** Students who demonstrate understanding can develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
5. **MS-PS3-5:** Students who demonstrate understanding can construct, use, and present evidence to explain that energy can be transferred from one object to another through electric currents, which can be used to power electrical devices.

### HIGH SCHOOL:

1. **HS-PS2-1:** Students who demonstrate understanding can analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration**.**
2. **HS-PS2-4:** Students who demonstrate understanding can use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
3. **HS-PS2-5:** Students who demonstrate understanding can plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
4. **HS-PS3-5:** Students who demonstrate understanding can develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

*(continued)*

## AP PHYSICS 2 AND AP PHYSICS C LEARNING OBJECTIVES

### 12.1 MAGNETIC FIELDS

- **10.1.A** Describe the electric force that results from the interactions between charged objects or systems.
- **10.2.A** Describe the behavior of a system using conservation of charge**.**
- **11.1.A** Describe the movement of electric charges through a medium.
- **11.5.C** Describe the measurement of current and potential difference in a circuit.
- **12.1.A** Describe the properties of a magnetic field.
- **12.1.B** Describe the magnetic behavior of a material as a result of the configuration of magnetic dipoles in the material.
- **12.2.B** Describe the force exerted on moving charged objects by a magnetic field.
- **12.3.B** Describe the force exerted on a current-carrying wire by a magnetic field.
- **12.4.A** Describe the induced electric potential difference resulting from a change in magnetic flux.

### AP PHYSICS SCIENCE PRACTICES

Students will use practices 2C (Compare quantities when there is a change in the scenario or at a later time in the scenario), 2D (Predict new values or factors of change using functional dependence in an expression – e.g. proportional reasoning), and 3B (Make claims using laws, definitions, or relationships) in these activities.