

## HS-PS2-5

Students who demonstrate understanding can:

- HS-PS2-5.** 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. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

| Science and Engineering Practices  | Disciplinary Core Ideas  | Crosscutting Concepts   |
|--|--|---|
| <p><b>Planning and Carrying Out Investigations</b><br/>           Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models.</p> <ul style="list-style-type: none"> <li>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.</li> </ul> | <p><b>PS2.B: Types of Interactions</b></p> <ul style="list-style-type: none"> <li>Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)</li> <li>Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.</li> </ul> <p><b>PS3.A: Definitions of Energy</b></p> <ul style="list-style-type: none"> <li>"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)</li> </ul> | <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</li> </ul> |

### Observable features of the student performance by the end of the course:

|   |   |
|---|---|
| 1 | Identifying the phenomenon to be investigated   |
|   | a Students describe the phenomenon under investigation, which includes the following idea: that an electric current produces a magnetic field and that a changing magnetic field produces an electric current.  |
| 2 | Identifying the evidence to answer this question  |
|   | a Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data about 1) an observable effect of a magnetic field that is uniquely related to the presence of an electric current in the circuit, and 2) an electric current in the circuit that is uniquely related to the presence of a changing magnetic field near the circuit. Students describe why these effects seen must be causal and not correlational, citing specific cause-effect relationships.         |
| 3 | Planning for the investigation  |
|   | a In the investigation plan, students include: <ul style="list-style-type: none"> <li>i. The use of an electric circuit through which electric current can flow, a source of electrical energy that can be placed in the circuit, the shape and orientation of the wire, and the types and positions of detectors;</li> <li>ii. A means to indicate or measure when electric current is flowing through the circuit;</li> <li>iii. A means to indicate or measure the presence of a local magnetic field near the circuit; and</li> </ul> |

|   |                     |   |
|---|---------------------|---|
|   |                     | iv. A design of a system to change the magnetic field in a nearby circuit and a means to indicate or measure when the magnetic field is changing.   |
|   | b                   | In the plan, students state whether the investigation will be conducted individually or collaboratively.  |
| 4 | Collecting the data |   |
|   | a                   | Students measure and record electric currents and magnetic fields.  |
| 5 | Refining the design |   |
|   | a                   | Students evaluate their investigation, including an evaluation of: <ul style="list-style-type: none"> <li>i. The accuracy and precision of the data collected, as well as limitations of the investigation; and</li> <li>ii. The ability of the data to provide the evidence required.</li> </ul> |
|   | b                   | If necessary, students refine the investigation plan to produce more accurate, precise, and useful data such that the measurements or indicators of the presence of an electric current in the circuit and a magnetic field near the circuit can provide the required evidence.                   |