MIDDLE SCHOOL PHYSICAL SCIENCE: FORCES OVER SPACE

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (SEP: 1; DCI: PS2.B; CCC: Cause/Effect) [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.*]

MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (SEP: 1; DCI: PS2.B; CCC: Cause/Effect) [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [*Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.*]

MS-PS2-5 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. (SEP: 3; DCI: PS2.B; CCC: Cause/Effect) [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [*Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Invisible forces exist between objects that have electric, magnetic, and/or gravitational properties. These forces can become stronger and weaker depending on the distance between the objects and the mass of the objects. There are factors that cause objects to repel one another and also factors that cause these objects to be attracted.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Rubbing a balloon on your sweater and then placing it near a water running out of the faucet will change the path of the water.
- Rubbing a balloon on your sweater and then placing it near your hair will make your hair stand on end.

- When you drag your feet across the carpet in your living room, you are able to create a shock on the doorknob without touching the doorknob.
- When I hold my compass and spin, the arrow will continue to point in the same direction.
- The moon continues to orbit around the earth; it does not fly off in a projectile.
- Combing my hair on a dry winter's day causes my hair to stand on end.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems ● Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Planning and Carrying Out Investigations** ● Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B: Types of Interactions** ● Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. ● Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	**Cause and Effect** ● Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Some forces act upon objects at a distance, and the interaction cannot be seen. Electrical forces occur between two electrically charged objects; magnetic forces occur between two magnetic objects; and gravitational forces occur between two objects that have mass. These forces are explained using fields, which can be mapped by the effect they have on an object. Changing the distance between the objects will increase or decrease the force the objects exert on one another. Increasing the distance between the objects will decrease the force the objects exert on one another. In these performance expectations, students are expected to create and carry out an investigation(s) that provides evidence that fields exist between objects even when the objects are not in contact.

Magnetic forces exist due to the orientation of atomic particles within the magnet. Each magnet is a dipole having a north and a south pole. The north pole of one magnet is attracted to the south pole of another magnet. Alternatively, the north pole of one magnet is repelled by the north pole of another magnet. Some objects are always magnets due to their composition, while other objects can become magnets using an electric current. For example, wrapping an iron nail with insulated wire and running electric current through the wire will result in an induced magnetic field, an electromagnet. When the current stops, the magnetic field collapses and the nail is no longer magnetic. In this case, the magnetic field can increase or decrease in strength according to the magnitude of the current or the number of coils around the nail. Other factors that affect the strength of the magnetic force include, composition of the object, size of the object and

distance between the magnets. Larger or closer magnets have a stronger magnetic force than magnets that are smaller or further apart.

The particles within objects can become electrically charged, either positively or negatively, when electrons of the object are added or removed. Electrically charged objects are attracted to objects with the opposite charge and repelled by objects with the same charge. Positive charges are attracted to negatively charged objects and repel from positively charged objects. The larger the object, the stronger the force will be. When the object is attracting another object, the closer they get to one another, the stronger their force will be. Likewise, the farther apart the objects get, the weaker their force is. When objects are similarly charged, their repelling force is stronger the closer they are and weakens the farther the objects are from one another.

Every object in the universe has mass, and mass exerts a gravitational pull on other objects. The mass of an object is the amount of matter within the object. Gravitational forces are always attractive and the mass of an object determines how strong the gravitational pull is. The gravitational force between any two masses depends on the size of the masses. The larger the mass, the larger the gravitational force. The force of gravity is what gives weight to an object and causes objects to fall toward Earth's center. When gravity is applied, the weight can be calculated (Weight = mass x acceleration due to gravity), The mass of an object cannot change, but in the absence or presence of gravity; the weight of an object can change (for example, the mass of an object is the same whether the object is on the moon or on Earth, but the object will weigh much less on the moon due to less gravitational force). All objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass (even masses that are small). These forces are always attractive.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30
http://stemteachingtools.org/brief/41
http://stemteachingtools.org/pd/sessionb

SEP Planning and Carrying Out Investigations

- Present students with an electromagnet made from a battery, iron nail, and insulated wire. Ask students to identify questions to ask, and ask students to evaluate different ways of observing and/or measuring to answer those questions. Then have students design and conduct an experiment to test the factors that will affect the electromagnet's efficiency.

SEP Asking Questions and Defining Problems

- After rubbing a balloon on your sweater it will stick to the wall. Ask students to generate scientific questions relevant to investigating that phenomenon, and ask students to describe what evidence is needed to answer the questions they generated.

CCC Cause and Effect

- Present students with a table showing the mass of planets and an object's weight on each planet. Can this study design provide evidence as to whether gravity causes weight? Explain why or why not.

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- Students can **ask questions to be investigated** to demonstrate that electric and magnetic forces can be attractive or repulsive, and using this demonstration *predict what could happen in other scenarios*.
- Students can **conduct an investigation** to produce data demonstrating the forces of static electricity and how these forces are *dependent* upon distance.
- Students can **ask questions to investigate** electric forces and *create a hypothesis* to determine factors that increase or decrease the strength of their force.
- Students can **design an investigation** to *determine* the strength of different magnets.
- Students can **ask questions to be investigated** to *determine how to increase* the strength of an electromagnet.
- Students can **design and conduct an investigation** to show the presence of gravitational forces between *different masses.*