Grade 6 Science, Unit 5

Types of Interactions

Overview

Unit abstract

In this unit of study, students understand ideas related to why some objects will keep moving, why objects fall to the ground, and why some materials are attracted to each other while others are not. Students apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students will develop understanding that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. The crosscutting concepts of cause and effect, system and system models, and stability and change serve as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to consider the influence of science, engineering, and technology on society and the natural world. They will demonstrate proficiency in asking questions, planning and carrying out investigations, designing solutions, and engaging in argument.

Essential questions

- How can one describe physical interactions between objects and within systems of objects?
- What type of interactions occurs between forces?

Bristol–Warren, Central Falls, Cranston, Segue Institute for Learning, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

Written Curriculum

Next Generation Science Standards

MS. Forces and Interactions

Students who demonstrate understanding can:

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.** [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 is limited to qualitative evidence for the existence of fields.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. ▪ 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. (MS-PS2-5)	**PS2.B: Types of Interactions** ▪ 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). (MS-PS2-5)	**Cause and Effect** ▪ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-5)

Connections to other DCIs in this grade-band: N/A

Articulation across grade-bands: **3.PS2.B** (MS-PS2-5); **HS.PS2.B** (MS-PS2-5); **HS.PS3.A** (MS-PS2-5); **HS.PS3.B** (MS-PS2-5); **HS.PS3.C** (MS-PS2-5)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-5)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-5)

MS. Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-3. **Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.** [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.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. ▪ 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. (MS-PS2-3)	**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. (MS-PS2-3)	**Cause and Effect** ▪ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3)

Connections to other DCIs in this grade-band: N/A

Articulation across grade-bands: **3.PS2.B** (MS-PS2-3); **HS.PS2.B** (MS-PS2-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS2-3)

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS2-3)

MS. Forces and Interactions

Students who demonstrate understanding can:

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.** [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.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. ▪ Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4) **----------** **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-4)	**PS2.B: Types of Interactions** ▪ Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4)	**Systems and System Models** ▪ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-4)

Connections to other DCIs in this grade-band: **MS.ESS1.A** (MS-PS2-4); **MS.ESS1.B** (MS-PS2-4); **MS.ESS2.C** (MS-PS2-4)

Articulation across grade-bands: **5.PS2.B** (MS-PS2-4); **HS.PS2.B** (MS-PS2-4); **HS.ESS1.B** (MS-PS2-4)

Common Core State Standards Connections:

ELA/Literacy –

WHST.6-8.1 Write arguments focused on discipline-specific content. (MS-PS2-4)

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study. By the end of Grade 5, students know that:

- Objects in contact exert forces on each other.
- Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.
- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Progression of current learning

Driving question 1
How can force fields be demonstrated?

Concepts	Practices
• Fields exist between objects that exert forces on each other even though the objects are not in contact. • The interactions of magnets, electrically charged strips of tape, and electrically charged pith balls are examples of fields that exist between objects exerting forces on each other, even though the objects are not in contact. • 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 relationships may be used to predict phenomena in natural or designed systems.	• Students will conduct an investigation and evaluate an experimental design to produce data that can serve as the basis for evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. • Students will identify the cause-and-effect relationships between fields that exist between objects and the behavior of the objects.

Driving question 2
How do electromagnetic forces behave and what affects their strength?

Concepts	Practices
• Factors affect the strength of electric and magnetic forces. • Devices that use electric and magnetic forces could include electromagnets, electric motors, and generators. • Electric and magnetic (electromagnetic) forces can be attractive or repulsive. • The size of an electric or magnetic (electromagnetic) force depends on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. • Cause-and-effect relationships may be used to predict the factors that affect the strength of electrical and magnetic forces in natural or designed systems.	• Students will ask questions about data to determine the effect of the strength of electric and magnetic forces 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. • Students will perform investigations using devices that use electromagnetic forces. • Students will collect and analyze data that 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.

Driving question 3
What factors affect the gravitational force between two objects?

Concepts	Practices
• Gravitational interactions are always attractive and depend on the masses of interacting objects. • There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. • Evidence supporting the claim that gravitational interactions are attractive and depend on the masses of interacting objects 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. • Models can be used to represent systems and their interactions, such as inputs, processes and outputs, and energy and matter flows within systems.	• Students construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. • Students use models to represent the gravitational interactions between two masses.

Integration of content, practices, and crosscutting concepts

Students will conduct investigations of fields that exist between objects exerting forces on each other, even though the objects are not in contact. Through first-hand experiences or simulations, students will observe and evaluate the behavior of objects and record evidence of fields that exist and are responsible for the observed behavior of the objects. Students can investigate the interactions between magnets, electrically charged strips of tape, and/or electrically charged pith balls. Through hands-on investigations or simulations, students will be able to observe how the motion or behavior of objects change when they are exposed to electric or magnetic fields. For example, a pith ball could be suspended from a lightweight string and students can apply a charge to a balloon, comb, or plastic rod and make observations about the motion of the pith ball when these objects are placed in close proximity to the ball. The same type of investigation could be conducted with magnets or strips of electric tape. If instruction starts with students making these observations, students could then generate questions that they could use to ask questions about the cause-and-effect relationships that could explain their observations. A short research project could be conducted to provide data that students would use to help them answer their self-generated questions.

Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to answer their self-generated questions.

Investigations can take place in the classroom, outdoor environment, or museums and other public facilities with available resources and when appropriate. Students will frame a hypothesis based on observations and scientific principles about the behavior of electromagnetic forces and carry out investigations to collect data about the factors that affect the strength of electric and magnetic forces. Examples of investigations 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. Students will analyze both numerical and symbolic data and use these data to determine the factors that affect the strength of electric and magnetic fields. Students will conclude this portion of the unit by citing specific textual evidence to support the analysis of information they access while reading science and technical texts or online sources about electric and magnetic forces*,* attending to the precise details of explanations or descriptions.

The next portion of this unit will focus on gravitational forces. Students will construct and present oral and written arguments using evidence to support the claim that gravitational interactions are always attractive and depend on the masses of interacting objects. Students will also understand that there is gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. Because of this, gravitational fields will only be observed through the observation of simulations, the use of models, or the analysis of data. These could include simulations or digital tools and charts displaying mass, strength of interactions, distance from the sun, and orbital periods of objects within the solar system. Models used need to represent gravitational interactions between two masses within and between systems.

Integration of DCI from prior units within this grade level

The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.

Integration of mathematics and/or English language arts/literacy

Mathematics

- Reason abstractly and quantitatively while using data to determine the factors that affect the strength of electric and magnetic forces.

English language arts/literacy

- Cite specific textual evidence to support analysis of information about science and technical texts regarding *the factors that affect the strength of electric and magnetic forces,* attending to the precise details of explanations or descriptions.
- Write arguments focused on evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Future learning

- Newton's second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
- 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.
- 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.
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- When two objects interacting through a field change relative position, the energy stored in the field is changed.

Number of Instructional Days

Recommended number of instructional days: 19 (1 day = approximately 50 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.