Grade 3 Science, Unit 3

Electrical and Magnetic Forces

Overview

Unit abstract

In this unit of study, students are able to determine the effects of balanced and unbalanced forces on the motion of an object and the cause-and-effect relationships of electrical or magnetic interactions to define a simple design problem that can be solved with magnets. The crosscutting concept of cause and effect, the interdependence of science, engineering, and technology, and the influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the third grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems. Students are expected to use these practices to demonstrate understanding of the core ideas.

Essential questions

- How do equal and unequal forces on an object affect the object?
- How can magnets be used?

Written Curriculum

Next Generation Science Standards

3. Forces and Interactions

Students who demonstrate understanding can:

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]

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 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. ▪ Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3)	**PS2.B: Types of Interactions** ▪ 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. (3-PS2-3)	**Cause and Effect** ▪ Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **MS.PS2.B** (3-PS2-3)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-PS2-3)

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-PS2-3)

RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). *(3-PS2-3)*

SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail. *(3-PS2-3)*

<table>
<tr><td colspan="3">3. Forces and Interactions</td></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.*
[Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]</td></tr>
<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><td>Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
▪ Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)</td><td>Disciplinary Core Ideas
PS2.B: Types of Interactions
▪ 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. (3-PS2-4)</td><td>Crosscutting Concepts
Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
▪ Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)</td></tr>
<tr><td colspan="3">Connections to other DCIs in third grade: N/A</td></tr>
<tr><td colspan="3">Articulation of DCIs across grade-levels: K.ETS1.A (3-PS2-4); 4.ETS1.A (3-PS2-4); MS.PS2.B (3-PS2-4)</td></tr>
<tr><td colspan="3">Common Core State Standards Connections: N/A</td></tr>
</table>

<table>
<tr><td colspan="3">3-5. Engineering Design</td></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.</td></tr>
<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><td>Science and Engineering Practices
Asking Questions and Defining Problems
Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
▪ Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)</td><td>Disciplinary Core Ideas
ETS1.A: Defining and Delimiting Engineering Problems
▪ Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)</td><td>Crosscutting Concepts
Influence of Science, Engineering, and Technology on Society and the Natural World
▪ People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)</td></tr>
<tr><td colspan="3">Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:
Fourth Grade: 4-PS3-4</td></tr>
<tr><td colspan="3">Articulation of DCIs across grade-bands: K-2.ETS1.A (3-5-ETS1-1); MS.ETS1.A (3-5-ETS1-1); MS.ETS1.B (3-5-ETS1-1)</td></tr>
<tr><td colspan="3">Common Core State Standards Connections:
ELA/Literacy –
W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1)
W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (3-5-ETS1-1)
W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (3-5-ETS1-1)
Mathematics –
MP.2 Reason abstractly and quantitatively. (3-5-ETS1-1)
MP.4 Model with mathematics. (3-5-ETS1-1)
MP.5 Use appropriate tools strategically. (3-5-ETS1-1)
3-5.OA Operations and Algebraic Thinking (3-5-ETS1-1)</td></tr>
</table>

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 the K–2 grade span, students know that:

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.

Progression of current learning

Driving question 1
What cause-and-effect relationships can be determined when electric or magnetic interactions occur between two objects not in contact with each other?

Concepts	Practices
• Cause-and-effect relationships are routinely identified, tested, and used to explain change. • 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.	• Identify and test cause-and-effect relationships in order to explain change. • Ask questions that can be investigated based on patterns such as cause-and-effect relationships. • Ask questions to determine cause-and-effect relationships in electric or magnetic interactions between two objects not in contact with each other. (Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.) • Magnetic forces could include – The force between two permanent magnets; – The force between an electromagnet and steel paperclips; – The force exerted by one magnet versus the force exerted by two magnets. • Cause-and-effect relationships could include – How the distance between objects affects the strength of the force – How the orientation of magnets affects the direction of the magnetic force.

Driving question 2
How can scientific ideas about magnets be applied to solve problems?

Concepts	Practices
• Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. • People's needs and wants change over time, as do their demands for new and improved technologies. • 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. • For forces between two magnets, the size of the force depends on their orientation relative to each other. • Possible solutions to a problem are limited by available materials and resources (constraints). • The success of a designed solution is determined by considering the desired features of a solution (criteria). • Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	• Define a simple problem that can be solved through the development of a new or improved object or tool. • Define a simple design problem that can be solved by applying scientific ideas about magnets (e.g., constructing a latch to keep a door shut or creating a device to keep two moving objects from touching each other). • Define a simple design problem that can be solved through the development of an object, tool, process, or system, and include several criteria for success and constraints on material, time, or cost. • Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Integration of content, practices, and crosscutting concepts

In this unit of study, third grade students will identify and test cause-and-effect relationships as they investigate electric and magnetic interactions between two or more objects. As students conduct simple investigations with these types of forces, they will observe the following patterns of change:

- Electric and magnetic forces between a pair of objects do not require that the objects be in contact.
- The size of an electric or magnetic force depends on the properties of the objects and their distances apart.
- The size of the force between two magnets also depends on their orientation relative to each other.

Students can discover these cause-and-effect relationships as they ask questions, conduct investigations, make observations, and use data to explain the interactions that occur between a variety of materials, such as human hair and an electrically charged balloon (static); two permanent magnets, oriented in a variety of ways; and an electromagnet and steel paper clips. In addition, students can investigate the difference in the size of force exerted by a single magnet versus the force exerted by two or more magnets.

After investigating electrical and magnetic forces, students will engage in a portion of the ***engineering design process*** in order to define a simple design problem that can be solved by applying scientific ideas about magnets. This process should include the following steps:

- As a class, create a list of the properties of magnets. (See previous paragraphs.)
- Brainstorm a list of everyday objects that use magnets, and discuss the function of the magnet(s) in each object. For example, electric can openers have a strong magnet that attaches a can to the device as it cuts through (opens) the top of the can.
- In small groups or pairs, students discuss possible everyday problems that might be solved using magnets. For example, they could construct a latch to keep a door shut.
- As a class, determine possible criteria that might be used to determine how successful the devices might be, and discuss possible constraints (on materials, time, or cost) that might affect each group's design solution.
- Small groups or pairs should have the opportunity to create a presentation (poster, PowerPoint, drawings, or actual physical model, if time permits) to share both the design problem and solution with the class.

In this unit, students are not expected to build and test their design solutions or to optimize their designs; however, they can compare different proposals for solutions on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. The overall goal is for students to understand that engaging in engineering design will help them understand that scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process, and that as people's needs and wants change over time, so do their demands for new and improved technologies.

Integration of engineering

Engineering design is an important part of this unit of study. Students are expected to define a simple design problem that can be solved by applying scientific ideas and determine possible success criteria and constraints on time, materials, and cost. They should also compare different proposals for solutions based on how well the proposed solutions meet the criteria for success or how well each takes the constraints into account. This process is outlined in greater detail in the previous section.

Integration of DCI from other units within this grade level

In Unit 2, Force and Motion, students planned and conducted investigations to determine the effects of balanced and unbalanced forces on the motion of an object. As they made observations, they identified patterns of change in order to describe cause-and-effect relationships in simple force-and-motion systems.

Integration of English language arts and mathematics

English language arts

In order to integrate the CCSS for English language arts, students should be given opportunities to conduct short research projects that build knowledge about electric and magnetic forces. They should be given multiple opportunities to recall and gather information from their investigations as well as from print and digital sources. Students should use that information to answer questions, describe cause-and-effect relationships, make comparisons, and explain interactions between objects when electrical or magnetic forces are involved. Teachers should provide a variety of texts for students to explore in order to develop students' note-taking skills. As students take notes, they should use graphic organizers, such as Venn diagrams and T-charts, to sort supporting evidence into provided categories. For example, as students read a variety of texts about forces, they can take notes and then sort the evidence they collect into categories, such as electrical and magnetic forces.

Mathematics

In order to integrate the CCSS for mathematics, students can use measurement tools in a variety of ways as they conduct investigations. They could find the mass of an object in order to understand that the more mass an object has, the greater the force needed to attract, repel, or move it. Students then reason mathematically as they analyze their data to determine patterns of change that can be used to support explanations of cause-and-effect relationships. Students might also use algebraic reasoning during investigations. For example, when measuring magnetic strength by increasing the number of magnets, students can use multiplication to make predictions about possible outcomes. So, if a paper clip moves toward a single magnet when it is 2 centimeters away, then students might predict that the paper clip will move toward a double magnet when it is 4 centimeters away. Or, if the paper clip moved towards a set of four magnets at a distance of 8 centimeters, then students might predict that the paper clip will move toward a single magnet when it is 2 centimeters away.

Future learning

The following disciplinary core ideas are future learning related to the concepts in this unit of study.

By the end of the 3–5 grade span, students know that:

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a design solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into accounts.

By the end of middle school, students know that:

- Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitude of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- 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).
- Forces that act at a distance (electrical, magnetic, and gravitational) can be explained by fields that extend through space, and these forces can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively).
- The more precisely a design task's criteria and constraints are defined, the more likely it is that the design solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.
- A solution needs to be tested and then modified on the basis of the test results to improve it.
- There are systematic processes for evaluation solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.

Number of Instructional Days

Recommended number of instructional days: 13 (1 day = approximately 45–60 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.