

Kindergarten Science, Unit 5

Pushes and Pulls

Overview

Unit abstract

During this unit of study, students are able to apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. The crosscutting concept of cause and effect is called out as the organizing concept for this disciplinary core idea. In the kindergarten performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations and analyzing and interpreting data. Students are expected to use these practices to demonstrate understanding of the core ideas.

Essential question

- What happens if you push or pull an object harder?

Written Curriculum

Next Generation Science Standards

K. Forces and Interactions: Pushes and Pulls		
Students who demonstrate understanding can:		
<p>K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]</p>		
The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<p style="text-align: center;">Science and Engineering Practices</p> <p>Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.</p> <ul style="list-style-type: none"> ▪ With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1) <p style="text-align: center;">-----</p> <p style="text-align: center;">Connections to Nature of Science</p> <p>Scientific Investigations Use a Variety of Methods</p> <ul style="list-style-type: none"> ▪ Scientists use different ways to study the world. (K-PS2-1) 	<p style="text-align: center;">Disciplinary Core Ideas</p> <p>PS2.A: Forces and Motion</p> <ul style="list-style-type: none"> ▪ Pushes and pulls can have different strengths and directions. (K-PS2-1) ▪ Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1) <p>PS2.B: Types of Interactions</p> <ul style="list-style-type: none"> ▪ When objects touch or collide, they push on one another and can change motion. (K-PS2-1) <p>PS3.C: Relationship Between Energy and Forces</p> <ul style="list-style-type: none"> ▪ A bigger push or pull makes things speed up or slow down more quickly. (secondary to K-PS2-1) 	<p style="text-align: center;">Crosscutting Concepts</p> <p>Cause and Effect</p> <ul style="list-style-type: none"> ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),
Connections to other DCIs in kindergarten: N/A		
Articulation of DCIs across grade-levels: 3.PS2.A (K-PS2-1); 3.PS2.B (K-PS2-1); 4.PS3.A (K-PS2-1)		
Common Core State Standards Connections:		
<p><i>ELA/Literacy</i> –</p> <p>W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1)</p> <p><i>Mathematics</i> –</p> <p>MP.2 Reason abstractly and quantitatively. (K-PS2-1)</p> <p>K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-PS2-1)</p> <p>K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has “more of”/“less of” the attribute, and describe the difference. (K-PS2-1)</p>		

K. Forces and Interactions: Pushes and Pulls		
<p>Students who demonstrate understanding can:</p> <p>K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.]</p>		
<p>The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i>:</p>		
<p style="text-align: center;">Science and Engineering Practices</p> <p>Analyzing and Interpreting Data</p> <p>Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.</p> <ul style="list-style-type: none"> ▪ Analyze data from tests of an object or tool to determine if it works as intended. (K-PS2-2) 	<p style="text-align: center;">Disciplinary Core Ideas</p> <p>PS2.A: Forces and Motion</p> <ul style="list-style-type: none"> ▪ Pushes and pulls can have different strengths and directions. (K-PS2-2) ▪ Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-2) <p>ETS1.A: Defining Engineering Problems</p> <ul style="list-style-type: none"> ▪ A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (<i>secondary to K-PS2-2</i>) 	<p style="text-align: center;">Crosscutting Concepts</p> <p>Cause and Effect</p> <ul style="list-style-type: none"> ▪ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-2)
<p><i>Connections to other DCIs in kindergarten:</i> K.ETS1.A (K-PS2-2); K.ETS1.B (K-PS2-2)</p>		
<p><i>Articulation of DCIs across grade-levels:</i> 2.ETS1.B (K-PS2-2); 3.PS2.A (K-PS2-2); 4.ETS1.A (K-PS2-2)</p>		
<p><i>Common Core State Standards Connections:</i></p> <p><i>ELA/Literacy –</i></p> <p>RI.K.1 With prompting and support, ask and answer questions about key details in a text. (<i>K-PS2-2</i>)</p> <p>SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (<i>K-PS2-2</i>)</p>		

K-2.Engineering Design		
Students who demonstrate understanding can: K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.		
The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
Science and Engineering Practices Analyzing and Interpreting Data Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. <ul style="list-style-type: none"> Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3) 	Disciplinary Core Ideas ETS1.C: Optimizing the Design Solution <ul style="list-style-type: none"> Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3) 	Crosscutting Concepts N/A
<p><i>Connections to K-2-ETS1.A: Defining and Delimiting Engineering Problems include:</i> Kindergarten: K-PS2-2, K-ESS3-2</p> <p><i>Connections to K-2-ETS1.B: Developing Possible Solutions to Problems include:</i> Kindergarten: K-ESS3-3, First Grade: 1-PS4-4, Second Grade: 2-LS2-2</p> <p><i>Connections to K-2-ETS1.C: Optimizing the Design Solution include:</i> Second Grade: 2-ESS2-1</p>		
<p><i>Articulation of DCIs across grade-bands: 3-5.ETS1.A (K-2 -ETS1-3); 3-5.ETS1.B (K-2-ETS1-3); 3-5.ETS1.C (K-2-ETS1-3)</i></p>		
<p><i>Common Core State Standards Connections:</i></p> <p><i>ELA/Literacy –</i></p> <p>W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. (K-2-ETS1-3)</p> <p>W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-3)</p> <p><i>Mathematics –</i></p> <p>MP.2 Reason abstractly and quantitatively. (K-2-ETS1-3)</p> <p>MP.4 Model with mathematics. (K-2-ETS1-3)</p> <p>MP.5 Use appropriate tools strategically. (K-2-ETS1-3)</p> <p>2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (K-2-ETS1-3)</p>		

Clarifying the standards

Prior learning

- There are no disciplinary core ideas that are considered prior learning for the concepts in this unit of study.

Progression of current learning

Driving question 1

In what ways do different strengths or directions of pushes or pulls affect the motion of an object?

Concepts

- Scientists use different ways to study the world.
- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- When objects touch or collide, they push on one another and can change motion.
- A bigger push or pull makes things speed up or slow down more quickly.

Practices

- With guidance, design simple tests to gather evidence to support or refute ideas about cause-and-effect relationships.
- With guidance, plan and conduct an investigation in collaboration with peers.
- With guidance, collaboratively plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include noncontact pushes or pulls such as those produced by magnets.) Some examples of pushes and pulls on the motion of an object could include:
 - A string attached to an object being pulled.
 - A person pushing an object.
 - A person stopping a rolling ball.
 - Two objects colliding and pushing on each other.

Driving question 2

In what ways can we change the speed or direction of an object with a push or a pull?

Concepts

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.
- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Practices

- With guidance, design simple tests to gather evidence to support or refute ideas about cause-and-effect relationships.
- Analyze data from tests of an object or tool to determine if it works as intended.
- Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- Analyze data to determine whether a design solution works as intended to change the speed or direction of an object with a push or a pull.
- Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects.
- Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn. (Assessment does not include friction as a mechanism for change in speed.)

Integration of content, practices, and crosscutting concepts

In this unit of study, students plan and carry out investigations in order to understand the effects of different strengths and different directions of pushes and pulls on the motion of an object. Students will also engage in a portion of the **engineering design process** to determine whether a design solution works as intended to change the speed or direction of an object.

Scientists often design simple tests in order to gather evidence that can be used to understand cause-and-effect relationships. In this unit's progression of learning, kindergarteners need adult guidance to collaboratively plan and conduct simple investigations to discover and compare the effects of pushes and pulls on the motion of an object. Students will need opportunities to push and pull a variety of objects, such as balls, toy cars, pull toys, cans, tops, and boxes. Students should push/pull these objects first with varying strengths, and then in a variety of directions. They should also explore the effects of pushing objects into one another, as well as into walls and other stationary objects. Students should record their observations using pictures and words, and should participate in class discussions on the effects of varying the strength or direction of a push or pull on an object. As students engage in these types of simple force and motion investigations, they will learn that:

- Pushes and pulls can have different strengths and directions.

- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- When objects touch or collide, the object's motion can be changed.
- The force of the push or pull will make things speed up or slow down more quickly.

To enhance students' experiences, teachers can schedule time for students to investigate these force and motion concepts using playground equipment, such as swings, seesaws, and slides. Teachers can also use trade books and multimedia resources to enrich students' understanding. As students participate in discussions, they should be encouraged to ask questions, share observations, and describe cause-and-effect relationships between forces (pushes and pulls) and the motion of objects.

As students come to understand the force and motion concepts outlined above, they should engage in the *engineering design process* as follows.

- Students are challenged to design a simple way to change the speed or direction of an object using a push or pull from another object.
- As a class, students determine what the design should be able to do (criteria). For example:
 - An object should move a second object a certain distance;
 - An object should move a second object so that the second object follows a particular path;
 - An object should change the direction of the motion of a second object; and/or
 - An object should knock down other specified objects.
- Students determine the objects that will move/be moved (balls, ramps, blocks, poker chips) and the types of structures (ramps or barriers) and materials (rubber bands, paper tubes, cardboard, foam, wooden blocks) that can be used to meet this challenge.
- Groups of students then develop a simple drawing or diagram and use given materials to build their design. Groups should be given a predetermined amount of time to draw and build their designs.
- Groups share their designs with the class, using their drawings or diagrams, and then test their designs.
- Students make and use observations to determine which of the designs worked as intended, based on the criteria determined by the class.

While engaging in this process, students should use evidence from their observations to describe how forces (pushes and pulls) cause changes in the speed or direction of an object.

Integration of engineering

In this unit of study, students learn that problem situations can be solved through engineering, and that because there is always more than one possible solution to a problem, it is useful to compare and test designs. Students will use what they have learned about the effect of pushes and pulls of varying strength and direction on the motion of an object to determine whether a design solution works as intended. This process is outlined in greater detail in the previous section.

Integration of DCI from other units within this grade level

In addition, the following connections to engineering design occur in Unit 1, Weather, Unit 4, The Human Factor, and Unit 6, Effects of the Sun.

In these units of study, kindergarten students learn 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.
- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.
- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Integration of English language arts and mathematics

English language arts

In order to integrate the Common Core State Standards for English language arts into this unit, students need the opportunity to participate in shared research that will enhance their understanding of the effect of forces (pushes and pulls) on objects. This could include exploring simple books and other media or digital resources. With prompting and support, students should ask and answer questions about key details in texts in order to seek help, get information, or clarify something that they do not understand. With support from adults, students will also recall information from experiences to answer questions and clarify their thinking. With support and/or collaboration, they can use digital tools to produce and publish simple informative writing or to document their observations of the simple force and motion systems they design and build.

Mathematics

During this unit of study, students will make connections to the Common Core State Standards for Mathematics in a number of ways. Kindergartners can use simple nonstandard units to measure the distances that two different objects travel when pushed or pulled or the distances that an object travels when varying the strength of a push or a pull. If using two objects, students can compare them using a measurable attribute, such as weight, to see which object has “more of” or “less of” the attribute, and describe the effect that increased weight has on the distance that an object travels. As students conduct multiple trials with the two objects (or with a single object, varying the strength of the push or pull), they can document the distance traveled in a simple graph. Then they can analyze the data in order to describe the cause-and-effect relationship between forces and motion of objects. As students collect and analyze data, they are learning to reason abstractly and quantitatively and use appropriate tools strategically.

Future learning

The following disciplinary core ideas are future learning for the concepts in this unit of study. By the end of Grade 2, students know that:

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

By the end of Grade 3, students know that:

- Each force acts on one particular object and has both strength and direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level.)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms,

such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

- 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.

By the end of Grade 4, students know that:

- The faster a given object is moving, the more energy it possesses.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

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 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.
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Number of Instructional Days

Recommended number of instructional days: 20 (1 day = approximately 20–30 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.

