Pushes and Pulls

Forces and Interactions

BOCES 4 Science

Teacher's Guide

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Written by teachers and administrators from public school districts within the borders of the NYS Midwest Joint Management Team in conjunction with the BOCES 4 Science Educators
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Foreword

BOCES 4 Science is a collaboration between four New York State BOCES (Board of Cooperative Educational Services). This collaborative of science educators came together to respond to the need for instructional resources based on the New York State pK-12 Science Learning Standards (NYSSLS). The research behind the Next Generation Science Standards (NGSS) and the NRC publication, A Framework for K-12 Science Education is the basis for the NYSSLS.

We believe that the future health and well-being of our world depends on scientifically literate people making informed decisions. The development of literacy in science begins at the earliest grades. Elementary children must have concrete experiences upon which to hook their understanding and new vocabulary – this is especially true in the discipline of science. We embrace the notion that students should experience phenomena and solve real problems to learn about the world. We strive to present lessons and materials that will make high quality science instruction available for all students through cost-effective resources for teachers.

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About this Unit

Overview

This **Pushes and Pulls unit** is designed for **Kindergarten**.

The main ideas included in this unit are forces, and how they can be described as a push or a pull. Pushes and pulls can speed up, slow down, or change the direction of an object's motion. Also addressed, is in what way a force is impacted by a change in size, weight, or shape of an object. All of the lessons in this unit are flexible. It is the teacher's decision, based on the students in the class, which lessons to teach, and in what order.

Scheduling

This unit is scheduled to be in the classroom for 6 weeks. There are approximately 10-12 science instructional sessions in this unit, based on 30-40 minutes each. Adjust your schedule accordingly. **Please return the unit promptly or to request an extension, call 585-352-1140.**

Materials to Obtain Locally

Some lessons require materials that are NOT supplied in the kit. These materials can be easily obtained by the teacher or the students. Materials that will need to be provided are indicated with an asterisk * in the lesson materials list and are also listed below:

- Chart Paper
- Toys that can be pushed or pulled (scooter, wagon, etc.)
- Digital Camera/Phone for Documenting Learning
- Safety Scissors
- Several Large Books such as dictionaries to act as risers for tracks
- Playground Equipment (slide, merry-go-round, swing)
- Desk Chair with Wheels
- Kickball
- Set of Bases for Running
- Cylinder Shapes like Paper towel rolls, empty cans, etc.
- Smocks or Old T- Shirts for Painting
- Printed Photos of Students taken during Unit- for captioning and making class book

Recommendations

It is highly recommended that you take photographs of the students as they progress through the lesson sequence. The photographs will prove useful in the final assessment. In addition, be certain to try out any online resources well in advance of needing them. And remember, just because it worked yesterday doesn't mean it will today!

Three Dimensions

Each of the BOCES 4 Science lessons includes at least one element from each of the three dimensions identified in the NYSSLS. The lesson page identifies the specific elements targeted; the NYSSLS topic page is included on p. 8-9 of the Teacher's Guide.

Science and Engineering Practices (SEP) – These are the major practices that scientists employ as they investigate and build models of their understanding of the world. They also include key practices used by engineers as they design and build systems.

Disciplinary Core Ideas (DCI) – Selected to represent four major domains: the physical sciences; the life sciences; the earth and space sciences: and engineering technology, and the applications of sciences.

Crosscutting Concepts (CCC) – These big ideas have application across all domains of science and provide one way of linking across the domains of the DCI's. In addition, they link to ideas that are parts of other elementary subjects.

NYSSLS Shifts in Instruction

It is the intention of BOCES 4 Science that this unit provides lessons that demonstrate the following shifts in instruction:

- **Explaining Phenomena or Designing Solutions to Problems:** The unit focuses on supporting students to make sense of a phenomenon or design solutions to a problem.
- **Three Dimensions:** The unit helps students develop and use multiple grade-appropriate elements of the SEPs, CCCs, and DCIs which are deliberately selected to make sense of phenomena or design a solution to a problem.
- **Integrating the Three Dimensions for Instruction and Assessment:** The unit will elicit student artifacts that show direct, observable evidence of three dimensional learning.
- **Relevance and Authenticity:** By taking advantage of student questions and experiences in the context of their homes, neighborhood and community, the lessons in this unit will motivate student sense-making or problem-solving.
- **Student Ideas:** This unit provides opportunities for students to express clarify, justify, interpret or represent their ideas and to respond to peer and teacher feedback.
- **Building on Students' Prior Knowledge:** Since student understanding grows over time, this unit identifies and builds on students' prior learning in three dimensions in such a way as it is explicit to both students and teachers.

Assessment:

Providing opportunities for assessment of learning and feedback to students is an important step in the educational process. This unit includes embedded formative assessments and a final summative assessment of learning. The teacher is encouraged to use a variety of informal or anecdotal assessment strategies as well, such as: portfolios of artifacts, "thumbs up" & "thumbs down", "ticket out the door", regular perusal of student science journals or having students keep an additional notebook to contain their reflections.

Additional Features of this Unit:

The **Pushes and Pulls** unit also includes Student Science Journal pages that are available in the kit and online at the BOCES 4 Science website. **www.boces4science.org**. (Password is located within the science kit.)

Additional resources for the teacher, such as the specific assessments, ELA and/or ELL supports, direct links to videos or websites mentioned in the teacher's guide, etc. can also be found on the BOCES 4 Science website.

Features that Support 3-D Learning

Look for these features in the Teacher's Guide:

NYS pK – 12 Science Learning Standards within each lesson provide the teacher with specific information about the Performance Expectation and the 3-Dimensions that are targeted by the instruction in this lesson.

Performance Expectations:

K-2-ETS1-2 – Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Science and Engineering Practices

Developing and Using Models

Develop a simple model based on evidence to represent a proposed object or tool.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- 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.

Crosscutting Concepts

Structure and Function

- The shape and stability of structures of natural and designed objects are related to their function(s).

ELA/Math/Social Studies Connections:

ELA: 2R1

Math: NY-2.MD

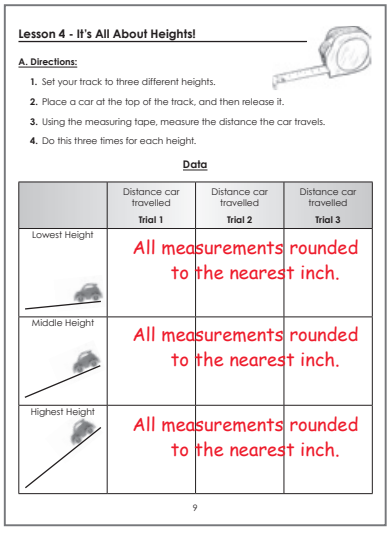
Social Studies:

Safety:

Students should always be reminded about not playing too roughly in the classroom, and to be respectful of others' space on the floor.

Throughout the Teacher's Guide, the 3-Dimensional Domains are color coded within the text so that teachers know to emphasize or explicitly point out to students this connection to either the **Science and Engineering Practices (SEPs)** and the **Crosscutting Concepts (CCCs)**. In addition, small boxes on the side of the Procedure serve as a visual reminder as well.

In addition, a small picture of the page(s) of the Student Science Journal (with answers) that students are using for each lesson has been included on the appropriate pages in the Teacher's Guide (see box to the right). This keeps the teacher from needing to go back and forth between various documents pertaining to a particular lesson.



Lesson 4 - It's All About Heights!

A. Directions:

1. Set your track to three different heights.
2. Place a car at the top of the track, and then release it.
3. Using the measuring tape, measure the distance the car travels.
4. Do this three times for each height.

Data

	Distance car travelled Trial 1	Distance car travelled Trial 2	Distance car travelled Trial 3
Lowest Height	All measurements rounded to the nearest inch.		
Middle Height	All measurements rounded to the nearest inch.		
Highest Height	All measurements rounded to the nearest inch.		

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CCC: Crosscutting Concept(s):

Cause and Effect:

Events have causes that generate observable patterns.

New York State P-12 Science Learning Standards

Forces and Interactions: Pushes and Pulls

Students who demonstrate understanding can:

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.]

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.]

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

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.

- With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1)

Analyzing and Interpreting Data

Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

- Analyze data from tests of an object or tool to determine if it works as intended. (K-PS2-2)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Scientists use different ways to study the world. (K-PS2-1)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Pushes and pulls can have different strengths and directions. (KPS2-1), (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-PS2-1),(K-PS2-2)

PS2.B: Types of Interactions

- When objects touch or collide, they push on one another and can change motion. (K-PS2-1) PS3.C: Relationship Between Energy and Forces
- (NYSED) A push or a pull may cause stationary objects to move, and a stronger push or pull in the same or opposite direction makes an object in motion speed up or slow down more quickly. (secondary to K-PS2-1)

ETS1.A: Defining Engineering Problems

- 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. (secondary to KPS2-2)

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS21),(K-PS2-2)

Pushes and Pulls

Connections to other DCIs in Kindergarten: **K.ETS1.A** (K-PS2-2); **K.ETS1.B** (K-PS2-2)

Articulation of DCIs across grade-levels: **2.ETS1.B** (K-PS2-2); **3.PS2.A** (K-PS2-1),(K-PS2-2); **3.PS2.B** (K-PS2-1); **4.PS3.A** (K-PS2-1); **4.ETS1.A** (K-PS2-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.K.1 With prompting and support, ask and answer questions about key details in a text. (K-PS2-2)

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)

SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)

Mathematics –

MP.2 Reason abstractly and quantitatively. (K-PS2-1)

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)

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)

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea. The text in the "Disciplinary Core Ideas" section is reproduced verbatim form A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas unless it is preceded by (NYSED).

Lesson 4

It's All About Heights!

Focus Question:
How does the height, or slope, of a ramp affect the distance a moving object travels?

Vocabulary:
faster
height
slower
trial

Lesson Synopsis

Learning Target(s):
I can investigate how the height of a ramp affects the distance a car travels down a ramp.

Lesson Description:
Using a long section of a Hot Wheels track to act as a ramp, students will observe and reflect on the relationship between the height of the ramp and the distance a car or other object released from the top will travel. Students will complete a data table that will assist them in discovering the relationship.

SEP: Science and Engineering Practice(s):

Planning and Carrying Out Investigations:
With guidance, plan and conduct an investigation in collaboration with peers.

Management

Materials

For the class:
1 Matchbox car
1 stop watch
Hot Wheels tracks
3-4 connectors
Slide photos (found in Teacher Resources online)
Several large books to serve as risers for the ramps*
Digital camera/phone*

For each student:
Student Science Journal p. 9-10

*provided by teacher/student

Safety:
Students should be reminded to release, not push, the cars down the ramp.

Preparation:
1. Divide your class into groups of three students.
2. Prepare a copy of a class Data sheet from the Student Science Journal to display on a Smartboard or projector.
3. Locate several large books (such as a set of dictionaries from the library) to serve as risers for the ramps, as well as a camera.

CCC: Crosscutting Concept(s):

Cause and Effect:
Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Teacher Background:

Increasing the **height** of a ramp increases the incline of the ramp, which in turn increases the distance an object travels down a ramp. This is assuming that all other factors pertaining to the ramp and the object remain the same, such as the material of the ramp and the material of the object.

Many young students are already familiar with these concepts because they have experienced sliding down hills on snow sleds, water slides, and other rides at carnivals or amusement parks. Think about a big water slide! They know that height matters, as it is usually correlated with higher speeds and more fun.

As the height of the ramp increases, the height of the object placed at the top of this ramp does too. An increase in height of an object from a surface corresponds to an increase in the potential energy of the object.

When the object is allowed to roll or slide down the higher, more inclined ramp to the surface, this higher potential energy can be converted into correspondingly higher kinetic energy. In other words, the object will go farther down the ramp.

Because kinetic energy is calculated from the mass of an object and its speed, the higher the ramp, the faster an object rolling or sliding down the ramp will be, assuming the mass of the object remains the same. Not all of the potential energy is converted into kinetic energy though, as some of this energy is lost as heat from the friction between the ramp and the object as the object goes down the ramp.

Standards

Performance Expectations:

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.]

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.]

Science and Engineering Practices

Planning and Carrying Out Investigations

- With guidance, plan and conduct an investigation in collaboration with peers.

Analyzing and Interpreting Data

- Analyze data from tests of an object or tool to determine if it works as intended.

Using Mathematics and Computational Thinking

- Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s).
- Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Pushes and pulls can have different strengths and directions. (KPS2-1), (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-PS2-1), (K-PS2-2)

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS21), (K-PS2-2)

Scale, Proportion, and Quantity

- Relative scales allow objects and events to be compared and descried (e.g., bigger and smaller; hotter and colder; faster and slower).

Next Generation ELA and Mathematics Standards:

ELA/Literacy: SL.K.3

Math: K.MD.A.1, K.MD.A.2

CCC: Crosscutting Concept(s):

Cause and Effect:

Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS21), (K-PS2-2)

SEP: Science and Engineering Practice(s):

Analyzing and Interpreting Data:

Analyze data from tests of an object or tool to determine if it works as intended.

SEP: Science and Engineering Practice(s):

Using Mathematics and Computational Thinking:

Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s).

Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

Vocabulary:

- **faster** - completing a task in less time
- **height** - how high something is in comparison to the ground, or another agreed upon surface
- **slower** - completing a task in more time
- **trial** - a try

Misconceptions:

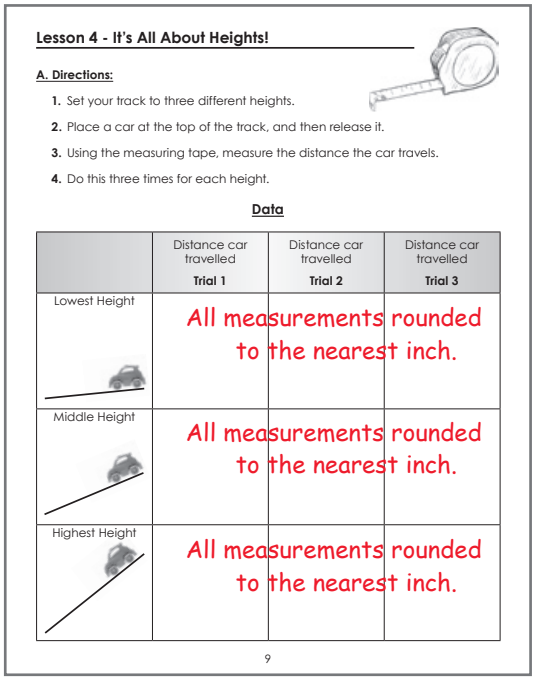
Kindergarteners are not ready to understand forces that they cannot see or feel, directly or indirectly. Although included in many trade books, introducing the concepts of gravity or friction at this age can lead to misconceptions that are very difficult to dispel.

Procedure

Phenomenon: **Objects traveling down ramps will go farther and faster, the higher the ramp.**

** Photographing the students throughout this unit will provide you with pictures that students may use in their final project.*

1. Begin the lesson by showing the students several pictures of water slides or sack slides and ask if any of them have ever experienced an activity or a carnival ride like them. There are a number of photo examples in the **Teacher's Resource Section online.**
2. **Direct the students to turn to the data sheet in their Student Science Journals p. 9. This is where they will record their observations.**
3. Working as a whole class, the students should connect several sections of Hot Wheels track together using connectors. Depending on the fine motor skills of your students, you may want to have the tracks already connected.
4. They will need to test at three distinct **heights**. I would suggest a few big books on the floor. You can borrow all the dictionaries from the library. The students are going to measure the distance a car travels down the ramp. They will repeat the same task three times, at three different heights.



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Data

	Distance car travelled Trial 1	Distance car travelled Trial 2	Distance car travelled Trial 3
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Highest Height	All measurements rounded to the nearest inch.		

9

5. For each trial, different students should be asked to release the car from the top of the track, mark the distance the car traveled on the floor, and measuring the distance the car traveled. The student releasing the car should be instructed not to push, but just to gently release the car at the top of the ramp.
6. Record the data in the Student Science Journal p. 9 and on the class record sheet displayed.

Closing the Lesson

1. Gather the students together and display the completed data sheet on your Smartboard
2. Ask why they think that they needed to repeat the measuring three times at each height. (to check for consistency and make sure there was not a mechanical problem with the car)
3. **Ask the students if they see a pattern to the data. (they should observe that the higher the ramp, the greater the distance the car traveled down the track)**

Assessment

The students should complete Part B in their Student Science Journals p. 10.


Lesson 4 - It's All About Heights! *(cont.)*

B. Directions: Write a sentence and draw a picture about what you learned in this lesson.

The learning should describe relationship between heights and distances.

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Connections

Differentiation: Students who have a great number of experiences with Amusement Parks or Water Parks could share their favorite location or ride and why.

Next Lesson Preparation

1. If possible, arrange in advance to switch recess times with one of you colleagues, or make other arrangements to try to avoid overcrowding on the playground during the lesson.
2. Weather necessitating, this lesson could take place in the gym, substituting scooters for the playground equipment.
3. Visit your playground and identify the equipment that can be moved with a push or a pull.
4. Mark the equipment in some way. Perhaps a colored piece of construction paper could be attached to the equipment with tape.

SEP: Science and Engineering Practice(s):

Planning and Carrying Out Investigations:

With guidance, plan and conduct an investigation in collaboration with peers.

CCC: Crosscutting Concept(s):

patterns:

Patterns in the natural and human designed world can be observed and used as evidence.