Sample Kindergarten - Physical Science

Knowing Science
3-DIMENSIONAL TEACHING & LEARNING

2.2 Forces and Motion

PURPOSE

This lesson centers on the relationship between force and motion. A force is a push or pull that gets something moving or stops something that is already in motion. An object that is at rest will stay at rest until a push or pull moves it. In this lesson, students will experience contact forces, classify forces as pushes or pulls, discover that heavier objects require more force to move, and that objects thrown with more force will travel a greater distance.

OBJECTIVES

By the end of the lesson, students will be able to:

- Differentiate between pushes and pulls
- Make predictions about the application of a force
- Measure and record on a chart the distance a thrown object travels
- Analyze data and draw conclusions about the effect of applying more or less force when throwing an object
- Relate the change of speed or direction of the motion to the action of a force

VOCABULARY

Introduce the following words during the course of the lesson. Make sure students have many opportunities to see the words in the classroom environment and to use the words as part of the lesson. There are definitions of the words at the end of the teacher's manual and in the optional *Student Activity Book*.

- Direction
- Faster
- Force
- Motion
- Pull
- Push
- Slower

PREPARING FOR THE LESSON

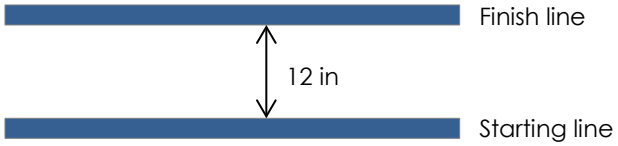
1. Before *Session 1* find enough space for the students to play tug of war. A hallway or a gym would be ideal.
   Also prepare an area for the bean bags activity. Tape a line on the floor using masking tape. Students should stand just behind this line and throw bean bags on the other side of the line. Allow enough empty space for students to throw.
   Prepare a *Throw Distance* table. Previously in this manual (see *Session 7* in lesson *1.2 Seeing the Difference: Comparing Height and Length*), students were introduced to the measuring tape as a tool used to count only the number of cubes. Unless you have introduced "inch" through other means, your students may not be familiar with this standard unit. If that is the case, the unit of length used for this activity should continue to be the "cube" (*i.e.* each space on the tape measure equals the size of one Eco Cube®). If students have already been introduced to inches, you should keep using this standard unit. During the activity you may need to help students in using and reading the measuring tape. Make sure they know where to place the starting and end points of the tape as well as pulling the tape taut to get an accurate reading.

Student's Name	Soft throw	Medium throw	Hard throw

2. Before *Session 2*, prepare the *Push/Pull* table

Pushes	**Pulls**

3. Before *Session 3*, put a strip of masking tape on the floor or table and call it the "starting line." Lay another strip of tape parallel to and about 12 inches away from the first one. This is the "finish line."



   Assemble the 3 Force Boxes and label them **A**, **B**, and **C**, or in any other way appropriate to young students (colors, animals, numbers, etc.). One of the boxes should be left empty while the remaining two should be filled, one with as many rubber balls as possible, the other one with two packs of marbles. Make sure that one box is the lightest, the second is medium weight, and the third one is heaviest. It is important that these weight differences are noticeable.

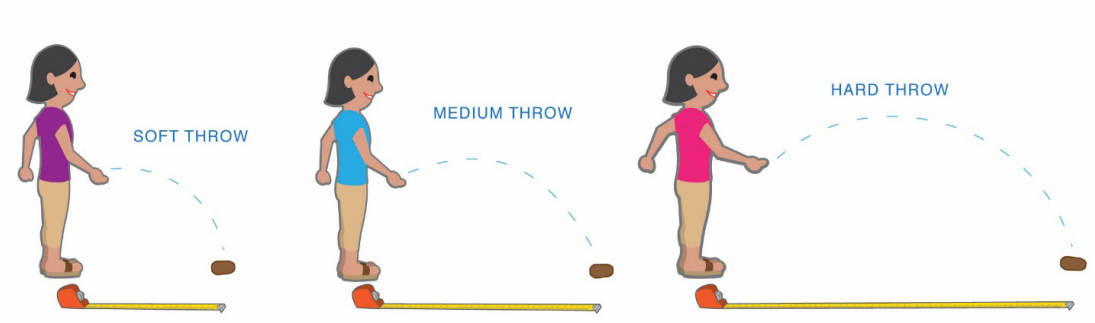
4. Before *Session 4*, select four hard cover books from your classroom or library.

Session 1: What's a push? What's a pull? (Part 1)
Time: 45 minutes
Materials: • Masking tape • Tug of War rope • 6 Bean bags • Tape measure (33 ft)
Session 2: What's a push? What's a pull? (Part 2)
Time: 45 minutes
Materials: • Laminated arrow • ***Oscar and the Cricket*** by Geoff Waring
Session 3: Does it take more force to move a heavier object?
Time: 45 minutes
Materials: • Masking tape • Force Boxes • 5 Packs of rubber balls • 2 Packs of marbles • 1 Double pan balance (Optional)
Session 4: How can we make something go faster? How can we make something change direction?
Time: 45 minutes
Materials: • ***Push and Pull*** by Patricia J. Murphy • 4 Cones • 2 Tennis balls • 2 Tracks • 4 hard cover books

TEACHING THE LESSON

Session 1: *What's a push? What's a pull? (Part 1)*

1. Ask students what they learned about motion in the previous lesson. **"How can you make something move?"** Guide a discussion that enables students to debate about what makes things move. Students may list actions that cause motion like kicking a ball, or pushing an object, or launching a paper airplane. Conclude the discussion by explaining that all those actions are expressions of a force. A force is something that make things (objects) move, changes the way they are moving, or slows them down.
2. Have two groups for a total of 8 students line up and face each other. Hold the rope and ask them to gently pull and see which side is pulling more. By placing a larger number of students on one side (for example 5) and a small number on the other (for example 3), students can feel the effect of a large force and a small force. If needed, explain to students how to play tug of war and remind students to not pull too much, something they will probably do anyway.
3. While the two groups are pulling, explain that the type of force each side is using is called a pull. A pull is any force that makes an object move toward us. Relate the definition to the tug of war game by explaining that each group is trying to pull the other side towards them.
4. By the end of the game students may complain that the game was unfair. If they don't complain, ask them if the game was fair in order to start a discussion. Remind students that this activity was an experiment. Ideally, students will notice that the side with more students was able to pull with more force and therefore prevail over the side with fewer students.
5. Bring the students to the area with the bean bags. Model for students the activity: throwing bean bags with increasing force:
    - Show students a small bean bag and throw it softly. Briefly discuss where it landed. Ask the students to predict whether you can throw the bean bag so that it goes farther: **"Do you think I can throw this bean bag so that it lands farther away than the first one?"** Allow time for students' responses. Students intuitively know that you should throw the bean bag harder to make it go a greater distance than the first bean bag.
    - Tell the students that you will throw the second bean bag harder. Students will see that the second bean bag has traveled farther than the first one.
    - Throw the third bean bag so that it lands farther away than the second one and ask, **"Why did that bean bag travel even further?"** Students should conclude that you must have thrown it harder—with more force. **"The first bean bag traveled a short distance because I used very little force. I used more force when throwing the second bean bag. Which bean bag did I throw with the most force?"** The students will recognize that you threw the third bean bag with the most force. Check to be sure students understand that *force* means the amount of strength—or push—used to throw the bean bag.



6. Explain to students that in a pull we pull an object toward us. Ask, **"Did I throw the bean bags toward myself? or away?"** [Away.] Tell students that forces that move things away from us are called a push.
7. Ask students, **"Do you think that the bean bags will always travel farther when they are thrown harder, or with more force?"** Allow time for student responses. Tell students that they will do an investigation to see if they get the same results you did, i.e., the more force you exerted on an object, the greater the distance the object traveled. Invite a student to stand on a line marked on the floor. Ask the student to throw the first bean bag softly, the second bean bag medium hard, and the third bean bag even harder. After each throw, have another student measure the distance the bean bag traveled with your help, and record the measurements in the *Throw Distance* table.
8. Repeat with several students. After all the data has been recorded, produce a bar-graph from the data to help students examine the collective results. They should be able to verify that the harder a bean bag was thrown, the greater the distance it traveled.

NOTE: The goal is to observe the effect of different amounts of force, not to compare the relative strengths of students' throwing arms. Therefore, each student's data will be recorded on a separate bar chart. After several students' charts have been displayed and examined, it will be easy to see that in all cases the bean bag traveled farthest when the most force was applied.

Session 2: *What's a push? What's a pull? (Part 2)*

1. Ask students to describe the action of pulling and pushing. When they pull something, they are moving an object closer to the force (i.e., themselves). When they push something, they are moving it away from the force (i.e., themselves). Use objects in the classroom as examples. Push or pull the door to open it, push or pull a book, or push or pull a ball. In each example use the arrow to indicate the direction of the force and the consequent direction of the motion of the object on which the force is applied. For a push, the arrow points away from you; for a pull, the arrow points toward you. Involve the students in this demonstration, asking them to push or pull classroom objects while you are holding the arrow. The whole class should participate in the discussion.
2. Read ***Oscar and the Cricket*** by Geoff Waring. In the story a cat called Oscar pushes and pulls objects causing them to move, stop, or change direction. Encourage students to recognize that Oscar is using a push or a pull and that the motion of an object changes as a consequence of the force applied.
3. If possible, take students on a "push/pull walk" inside and outside (if the weather permits) the school. Ask them to find 10 examples of pulling and pushing (e.g., students running on the playground, cars coming to a stop, custodian mopping the floor, a teacher pushing a supply cart, a child pushing another child on a swing). If a "push/pull walk" is not possible just ask students to list examples of their daily experiences of pushes and pulls.
4. After students have returned from their walk, use the *Push/Pull* table to help students classify each of the examples they saw. The following is an example of the beginning of such a table:

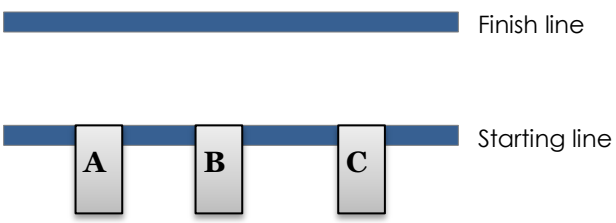
Pushes	Pulls
Girl hitting a softball	Teacher pulling down a window shade
Woman pushing a stroller	Student lifting his backpack

   Ask the students to explain each of the examples they saw and indicate why the force involved was pushing or pulling.

Session 3: *Does it take more force to move a heavier object?*

1. Remind students about the concept of force as something that can change the motion of objects. Demonstrate again the difference between a push and a pull, using objects in the classroom to help students visualize pushes and pulls. Then ask, **"Does it take the same amount of force to move any object?"** Allow students to discuss the question for a minute or so, and then ask for their responses. Make sure students construct explanations for their answers. If needed, remind students of their activity with the bean bags. In order to make a bean bag move farther away, they had to give it a stronger push.

2. Set the 3 ***Force Boxes*** on the starting line, and ask a student volunteer to use a single push, a flick of the finger, on each of the three boxes to push each toward the finish line. Ask the volunteer if pushing each box required the same amount of force. If not, which box required the most force, the least force, and some amount of force between the first two. Write the student's name on the four-column chart and indicate the letter of the box that matches the amount of push force he or she experienced. Continue the process until all students have had a chance to manipulate the three boxes. Students may also want to feel the relative weight of the boxes. If they don't pick up the boxes, you should suggest that they do. The beginning of the chart might look something like the example below:



Name	Most force	Moderate force	Least force
Isaac	Box A	Box B	Box C
Lola	Box A	Box C	Box B
Sam	Box A	Box B	Box C

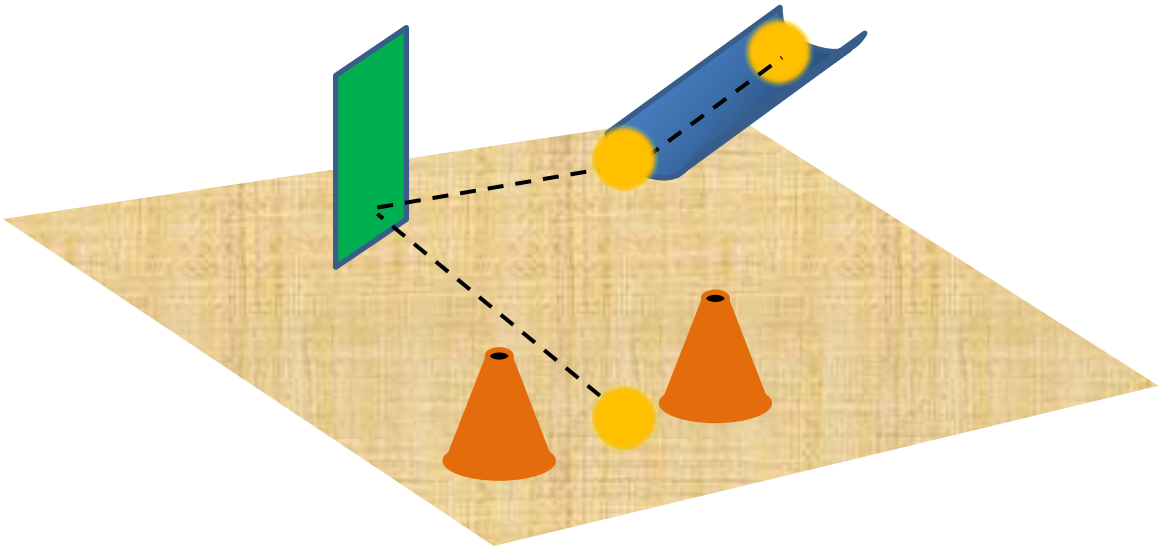
In this example, one student disagreed about which box required the least force to push. This may happen if there isn't significant difference in weight among the three boxes. Most likely, however, all the responses will be the same.
Ask the students what conclusion they can draw from looking at the chart and from what they know about the three boxes. If they have difficulty, guide them to understand that the heavier the object, the more force is required to push it. As an example, ask students if it requires more force to push a real car that weighs a few tons or a toy car that weighs a few ounces.

3. As an optional activity students may want to compare each of the boxes on a double pan balance to determine the order of weights.

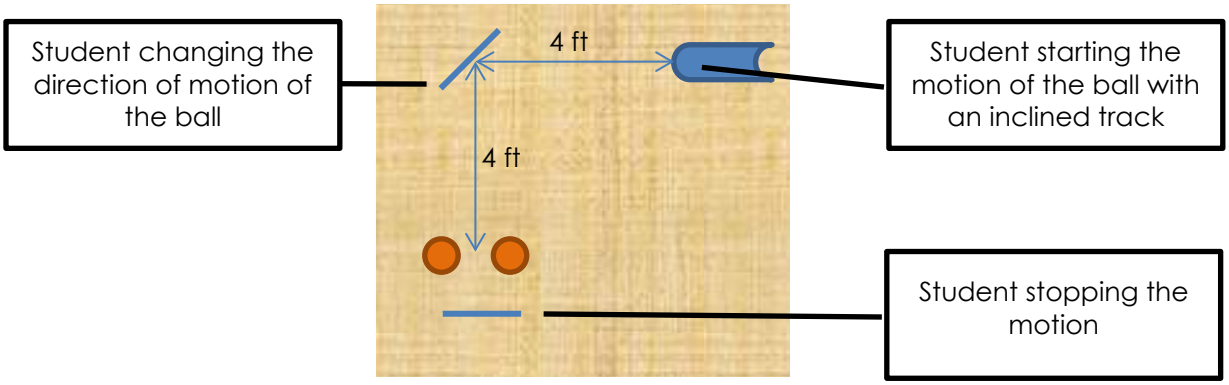
4. Write a list of five sample objects on an easel pad. Such a list could include a fire truck, a friend seated in a swing, a granola bar, a feather, a standard size car. Ask them to rank order the list by the object requiring the most force to push or pull, to the object requiring the least force to push or pull.

Session 4: *How can we make something go faster? How can we make something change direction?*

1. Gather the students around you and show them page 28 and read page 29 of ***Push and Pull***. Explain that when they are pushing or pulling they are applying a force. A force is either a force that pushes or a force that pulls. Remind students that forces make things move. Ask if they know what kind of game the boy on page 28 of ***Push and Pull*** is playing. [Marbles.]
2. Tell students that they will now play a game similar to mini-golf. Divide the class in groups of three students and explain that each group has one trial. This activity is purely exploratory and students will learn how to use the books and the track to obtain different results.
3. Distribute a track to one student in the group and show the student how to hold it like an inclined plane. Show the second student how to use a hard cover book to let the ball bounce and change direction. Show the third student how to hold the second hard cover book to stop the ball. Explain that the objective of the game is having the ball stop between the two cones.



If you have enough space you can set up two game areas. The position of the students and the cones is as follow:



4. Students should observe how other players are handling the situation. Make sure they notice that
   a. Changing the inclination of the track will change the ball's velocity;
   b. Changing the direction of the first hard cover book, will cause the ball to bounce in different directions;
   c. The second hard cover book can be used to slow down the ball progressively if the book is not held too strongly.
5. Once all students have tried to play the game, you might repeat the activity if time permits.
6. Conclude the lesson by having a conversation with students on the following questions:
   a. **"What have they learned about how to make a ball start moving using the track?"** [The more the track is inclined the faster the ball.]
   b. **"Why does the first hard cover book change the direction of motion of the ball?"** [The ball bounces on the book.] This is a push from the book.
   c. **"Is the third student using a push to stop the ball?"** [Yes.] The student is applying a force against the motion to slow the ball.

BUILDING LANGUAGE FOR LITERACY

1. Use the following sentence frames to model how to explain the relationship between force and motion. For example, "The more force I used, the longer the distance the object moved." or "The less force I used, the shorter the distance the object moved."

   The _(more/less)_ force I use, the _(longer/shorter)_ the _(object)_ moved.

   The _(heavier/lighter)_ the object, the _(more/less)_ force I used to push it.

   Model how to substitute other words that mean the same thing as *more force* (e.g., stronger, harder) and *less force* (e.g., softer, lighter). The goal is for students to be able to state the relationship between force and distance.

2. Use the following sentence frames to provide continued practice comparing how hard or how easy it is to apply a force. For example, if asked, "Is it is easier or harder to pick up an empty or a filled box?" the response is, "It is easier to pick up an empty box."

   It is _____ to pick up a button than a puppy.

   It is _____ to push a marble than a wagon.

   It is _____ to pull sled than your family's car.

   Students should also compare speeds.

   A car is _____than an airplane.

   An airplane is _____ than a car.

   The goal is for students to utilize the correct vocabulary for comparison. This helps in the development of content comprehension.

EXTENDING THE LESSON

1. Ask students to act out examples of pushing and pulling.
2. Ask students to have their parents help them make a list of 10 items they push or pull around the house.
3. Design solutions to use the remote control car to push or pull simple light objects.

ASSESSING STUDENT LEARNING

You can use a rubric such as the one below to assess students' learning.

	Emerging	Achieved	Advanced
Differentiates between pushes and pulls	Student requires significant teacher prompting to differentiate between a push and a pull.	Student can differentiate between a push and a pull with little teacher prompting.	Student can independently differentiate between and push and a pull, using the vocabulary of the lesson.
Makes a prediction about the effect of applying more or less force when throwing an object	Student makes an attempt to predict what will happen but is unable to explain his/her thinking.	Student makes a prediction using age-appropriate language.	Student makes a prediction and gives an explanation for his/her thinking, using age-appropriate language or scientific vocabulary.
Describes how to start an object at rest moving and how to stop or change the direction of a moving object	Can describe with substantial teacher assistance.	Can describe with minimal teacher assistance.	Can describe independently and offer examples.
Explains that a force is a push or a pull on an object	Can explain only with substantial help from the teacher.	Can explain with minimal help from the teacher.	Can explain independently and offer examples.

CROSSCUTTING CONCEPTS

Patterns; Cause and effect; Scale, proportion, and quantity

In this lesson, students begin to ask questions about observable phenomena. If they push something harder does it go further? Is it harder to pull a box of books than an empty box? Asking these questions will eventually lead them to see that the amount of force applied influences the speed and direction of moving objects. When students identify something as "easier" or "harder", they encounter the concept of relative scales.

SCIENTIFIC AND ENGINEERING PRACTICES

Planning and Carrying Out Investigations; Using Mathematics and Computational Thinking

STANDARDS CORRELATIONS

Next Generation Science Standards

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

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed of direction of an object with a push or a pull.

Common Core State Standards for English Language Arts

Reading Standards for Informational Text K-5

Key Ideas and Details: K.1

Craft and Structure: K.4

Integration of Knowledge and Ideas: K.7

Range of Reading and Level of Text Complexity: K.7

Speaking and Listening Standards K-5

Comprehension and Collaboration: K.1

Presentation of knowledge and ideas: K.4

Common Core State Standards for Mathematics

Counting and Cardinality: K.CC.3

Measurement and Data: K.MD.2

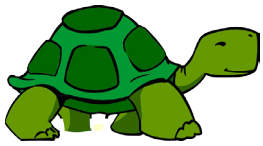
Glossary

Direction

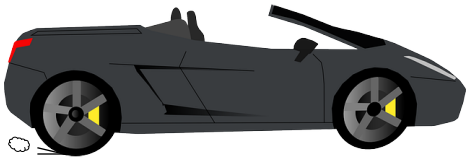
Lessons: *2.2 Forces and Motion*

Fast(er)

Slower



Faster



Lessons: *2.2 Forces and Motion*

Force

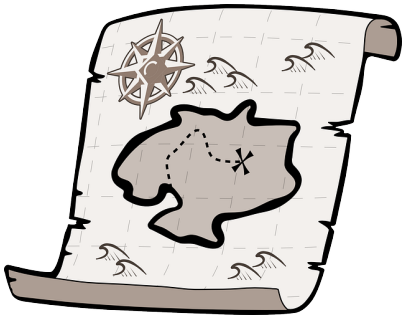
Push

Pull

Lessons: *2.2 Forces and Motion*

Motion

Moving, going from one place to another



Lessons: *2.2 Forces and Motion*

Pull

Moving something toward yourself

Lessons: *2.2 Forces and Motion*

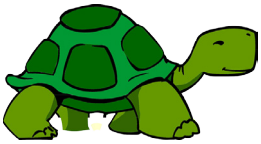
Push

Moving something away from yourself

Lessons: *2.2 Forces and Motion*

Slow(er)

Slower



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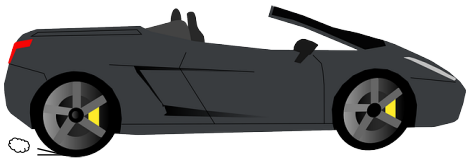

Lessons: *2.2 Forces and Motion*