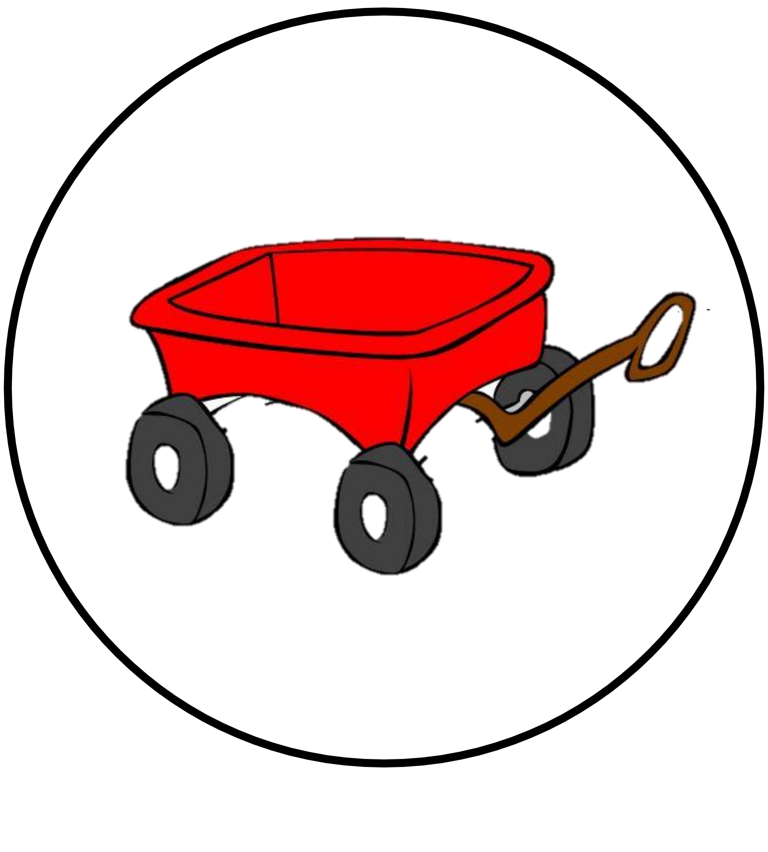
Advancing STEM
New York State Science Learning Standards

It's a Matter of Pushing or Pulling:
How Objects Move



Major support for and work on this project has been provided by the Cattaraugus-Allegany-Erie-Wyoming BOCES and Erie 2 Chautauqua Cattaraugus BOCES Region school districts. Extended thanks and appreciation to the teachers involved in the curriculum writing process.

Cattaraugus-Allegany-Erie-Wyoming BOCES Participating Districts

Allegany-Limestone Central School
Andover Central School
Belfast Central School
Bolivar-Richburg Central School
Cattaraugus-Little Valley Central School
Cuba-Rushford Central School
Franklinville Central School
Friendship Central School
Genesee Valley Central School
Hinsdale Central School
Pioneer Central School
Randolph Central School
Scio Central School
Wellsville Central School
West Valley Central School
Whitesville Central School

Erie 2 Chautauqua Cattaraugus BOCES Participating Districts

Bemus Point Central School
Brocton Central School
Cassadaga Valley Central School
Chautauqua Lake Central School
Clymer Central School
East Aurora Union Free School
Forestville Central School
Holland Central School
Jamestown Public School
Lake Shore Central School
Panama Central School
Sherman Central School
Silver Creek Central School
Springville-Griffith Institute Central School

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Updated: April 2017

Thank you for selecting an Advancing STEM Kit to enhance the teaching of science in your elementary classroom. Much care has been taken to ensure these kits align with the New York State Science Learning Standards, are academically rigorous, developmentally appropriate, and provide students with hands-on, engaging, and relevant learning experiences. These kits were developed by classroom teachers in districts in the Cattaraugus-Allegany and Erie 2 Chautauqua Cattaraugus BOCES regions, and are under constant review. If you have feedback for our program, please do not hesitate to contact us.

Three Dimensional Teaching

The Next Generation Science Standards (NGSS), upon which the New York State Science Learning Standards are built, incorporate three dimensions of knowledge, skills, and practices. They are:

Dimension 1: Science and Engineering Practices

This dimension focuses on students emulating the behaviors of scientists and engineers. The focus is not just on skills, but on the incorporation of knowledge. These practices include building models and developing theories about the natural world.

Dimension 2: Crosscutting Concepts

This dimension incorporates knowledge that spans science and engineering fields, linking ideas from one area of science to another. The focus of this dimension is on explicitly teaching the concepts of: Patterns; Cause and Effect; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; Structure and Function; Stability and Change.

Dimension 3: Disciplinary Core Ideas

The disciplinary core ideas are grouped into four domains: Life Sciences; Physical Sciences; Earth and Space Sciences; and Engineering, Technology and Applications of Science. To be considered core, ideas should meet at least two of the following criteria:

- Have **broad importance** across multiple sciences or engineering disciplines or be a **key organizing concept** of a single discipline;
- Provide a **key tool** for understanding or investigating more complex ideas and solving problems;
- Relate to the **interests and life experiences of students** or be connected to **societal or personal concerns** that require scientific or technological knowledge;
- Be **teachable and learnable** over multiple grades at increasing levels of depth and sophistication.

True NGSS-aligned instruction happens when teachers are able--through well-designed instructional practices and approaches--to merge these three dimensions into in-depth understanding for students.

Unit Design

This unit has been designed based on the 5E Lesson Planning structure. The 5E's provide a framework for curriculum, unit, and individual session design in the sciences.

The 5E's are:

Engage

This session initiates the learning tasks. The activities (1) activate prior knowledge and make connections between past and present learning experiences, and (2) anticipate activities and focus students' thinking on the learning outcomes of current activities. The learner should become mentally engaged in the concepts, practices, abilities, and skills of the curriculum unit.

Explore

This phase provides students with a common base of experiences within which they identify and begin developing concepts, practices, abilities, and skills. Students actively explore the contextual situation through investigations, reading, web searches, and discourse with peers.

Explain

This phase focuses on developing an explanation for the activities and situations students have been exploring. They verbalize their understanding of the concepts and practices. The teacher introduces formal labels, definitions, and explanations for concepts, practices, skills, and abilities.

Elaborate

This session extends students' conceptual understanding through opportunities for students to apply knowledge, skills, and abilities. Through new experiences, the learners transfer what they have learned and develop broader and deeper understanding of concepts about the contextual situation and refine their skills and abilities.

Evaluate

This phase emphasizes students assessing their understanding and abilities and provides opportunities for teachers to evaluate students' understanding of concepts and development of goals identified in learning outcomes.

You will notice that throughout the units, sessions have been designed to engage students and allow opportunities for exploration of topics and concepts, provide pausing points for teachers to explain and elaborate, and to evaluate the knowledge and application of the crosscutting concepts, disciplinary core ideas, and science and engineering practices.

Each unit begins with a driving question, a list of concepts covered, and a description of the culminating assessment. A unit may range from 15-20 learning experiences, and is intended to be taught over the course of 4-6 weeks. A typical learning experience may last between 25-40 minutes.

Assessments

Formative assessments have been embedded throughout the unit. The unit culminates with either an assessment utilizing the Engineering Design Process or a Performance Based Task. Please plan on assessments taking anywhere from 3-7 days for students to accomplish the task. A rubric has been designed and embedded within the unit to aid in the evaluation process. Where applicable, answer keys (if needed) have been provided for your convenience.

Live Materials

Any life science based unit includes instructions for accessing and/or ordering live materials. Please read this information carefully and follow any timelines provided to ensure adequate shipping and arrival of live materials.

Scientist's Notebook

To help students track their understanding and growth, students are provided with a **Scientist's Notebook**. This is a collection of all of their worksheets, a glossary for their vocabulary, and a place for them to keep notes and/or observations.

Digital Resources

Throughout the units, you will notice links and references to digital resources. These may include videos, apps, and/or websites. If you need assistance accessing these materials, please do not hesitate to reach out to us.

Vocabulary

Vocabulary development and instruction are key components to high-quality science instruction and student achievement. As such, we highly encourage the use of explicit and direct instructional techniques when it comes to introducing and mastering key vocabulary terms within the science concepts and units. Included in the **Scientist's Notebook** is a glossary for students to document their new vocabulary, using the Frayer Model. The Frayer Model asks students to create a visual model of their learning by defining the target word and determining examples and non-examples. More information on the Frayer Model can be found at:
http://www.theteachertoolkit.com/index.php/tool/frayer-model

It's a Matter of Pushing or Pulling: How Objects Move

Grade K

Unit Overview

Students will explore patterns in different systems that move and how they operate, as each system moves in a different but predictable pattern. Students will then design and build a contraption to change the speed or direction of an object with a push or a pull. As a result, students build a grade-level-appropriate concept of systems and an understanding of moving objects.

Scheduling

This kit contains one strand and an Engineering Design Challenge.

- Strand One focuses on pushes and pulls and their effect on objects. The strand contains six sessions.
- The Engineering Design Challenge will task students with analyzing data to determine if a design solution works as intended to change the speed or direction of an object with a push or pull and will take up to five sessions to complete.
- Please note that a session may take more than one class period.
- There are no live materials in this kit.

Safety Concerns

There are no safety concerns in this kit.

Extra Materials

Most materials for this unit are included; however, some materials will need to be provided by the teacher. These include:

- student chair
- writing utensils for students

Reminders

- Please follow all safety protocols as listed in the manual.
- Always remind students to wash their hands after handling any of the materials in the kit.
- Small objects should be handled with care.
- All materials in this kit are intended for instructional use only.
- Please return any extra consumable materials to help control costs of the kits.

Suggested Timeline

	Day 1	Day 2	Day 3	Day 4	Day 5
Week 1	Strand One: Engage	Strand One: Explore 1	Strand One: Explore 2	Strand One: Explain	Strand One: Elaborate
	Page: 6	Page: 9	Page: 12	Page: 14	Page: 17
	• *Force and Motion* song	• Explore forces used to move objects	• Read *Newton and Me* • Identify pushes and pulls	• Reread *Newton and Me* • Complete **Push, Pull, Both?** chart	• Push investigations using a wagon and weights • Complete **Push Investigation** chart
Week 2	Strand One: Evaluate	Engineering Design Challenge - Session 1: Ask	Engineering Design Challenge - Session 2: Imagine Engineering Design Challenge - Session 3: Plan	Engineering Design Challenge - Session 4: Create	Engineering Design Challenge - Session 5: Improve
	Page: 21	Page: 28	Page: 30, 32	Page: 34	Page: 36
	• Identify whether picture cards illustrate a push, a pull, or both • Complete **Evaluation Chart** using **Evaluation Cards**	• Ramp investigation using marbles and blocks to determine effect of speed on push • Complete **Engineering Design Process: Ask**	• Design solutions that will turn a marble to push over blocks • Complete **Engineering Design Process: Imagine** • Plan solutions • Complete **Engineering Design Process: Plan**	• Test solutions and record results • Complete **Engineering Design Process: Create**	• Review results and revise solutions from Session 4: Create • Time permitting, retest improved solutions

Dear Families,

Learning about our natural world is an exciting part of the elementary school curriculum. As we explore, we will come back time and again to elements of STEM: Science, Technology, Engineering, and Math.

Shortly, we will begin our next topic of study, which will focus on Forces and Interactions: Pushes and Pulls, a domain of Physical Sciences.

As we explore this topic, essential understandings will include:

- pushing an object can change its speed and direction
- pulling an object can change its speed and direction

Our final assessment for this unit will consist of an Engineering Design Challenge where students will analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or pull. For this assessment, students will construct a ramp and collect data on the number of blocks different size marbles will knock down from various heights. Additionally, students will explore how changing the direction of the marble impacts the data.

As always, please don't hesitate to contact me with any questions.

Thanks!

Strand One: Introduction

K. 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.]		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 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 investigations 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)	**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)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1), (K-PS2-2)

Common Core State Standards Connections

ELA/Literacy

RI.K.1 With prompting and support, ask and answer questions about 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 has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

Concepts

- pushing an object can change its speed and direction
- pulling an object can change its speed and direction

Standards Progression

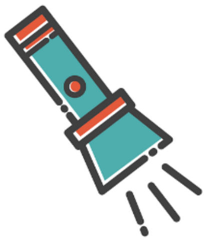
The NYS Science Learning Standards are a progression of core ideas that are introduced and elaborated upon throughout the grade levels. The standards for this grade level are detailed above.

Students will interact with these core ideas again in grades 3 and 4.

Strand Summary

This strand will help students discover the patterns of how objects move. Students will build understanding by exploring different systems that move and how they operate, as each system moves in a different but predictable pattern. The culminating activity, an Engineering Design Challenge, will ask students to analyze data to determine how changing the speed or direction of a push or pull impacts an object.

Strand One: Engage



Remember: This session initiates the learning tasks. The activities (1) activate prior knowledge and make connections between past and present learning experiences, and (2) anticipate activities and focus students' thinking on the learning outcomes of current activities. The learner should become mentally engaged in the concepts, practices, abilities, and skills of the curriculum unit.

Objectives

I can sing a song, *Force and Motion*, to learn about the forces of push and pull.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For the class:

- ***Force and Motion*** poster

Preparation

- Display the poster ***Force and Motion*** for the class to see while learning the song. The song can also be found on page 5 in the **Scientist's Notebook**.

Assessment

Students learn and sing the song *Force and Motion*.

Vocabulary

- push
- pull
- force
- motion

Engage Activity

1. Begin by teaching the students a new song, *Force and Motion*, sung to the tune of "Mary Had a Little Lamb." The words to the song can be found on page 5 in the **Scientist's Notebook**. Display the poster as well.

Force and Motion
Force can be a push or pull, push or pull, push or pull,
Force can be a push or pull.
It can move things to and away from me.

Motion is the way things move, way things move, way things move.
Motion is the way things move,
It moves things many ways.

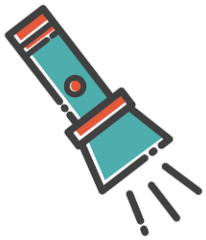
Force *and* Motion

To the tune of "Mary had a Little Lamb"

A force can be a push or pull,
push or pull,
push or pull
A force can be a push or pull,
It moves it to and away from me.

Motion is the way things move
Way things move
Way things move
Motion is the way things move
It moves things many ways!

Strand One: Explore 1



Remember: This phase provides students with a common base of experiences within which they identify and begin developing concepts, practices, abilities, and skills. Students actively explore the contextual situation through investigations, reading, web searches, and discourse with peers.

Objectives

I can explore the forces of push and pull with a ball and a chair.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For the class:

- tennis ball
- 2' segment of rope
- classroom chair (not provided)

Preparation

- Clear a space on the floor for students to be able to sit in a circle and move a ball and then a chair as part of the activity. Tie the rope around a leg of the chair near the seat to ensure stability.

Assessment

Students contribute to the discussion of what force is being used to move the ball and then the chair.

Vocabulary

- push
- pull
- force

Explore 1 Activity

1. Assemble students in a circle that is big enough to have room to push the tennis ball back and forth.

2. Place the ball in the center of the circle.
    a. **Ask**: Can the ball move on its own? If (student's name) wants to move the ball to (student's name) without picking it up, how can s/he do that?
    b. **Note:** Be sure the floor where the ball is placed is flat and does not allow the ball to move due to gravity from a slope.

3. Take turns having students push the ball to each other. During this portion of the activity, students should only be pushing the ball away from them to another classmate.
    a. **Note**: Use popsicle sticks or some other selection method to ensure each student has a chance to push the ball.

4. Discuss with students how they were able to get the ball from one student to another after each one has had a chance to push the ball away from them. Be sure to talk about push as a force that moves an object away from you.
    a. **Ask:** What did you need to do to move the ball to another student?

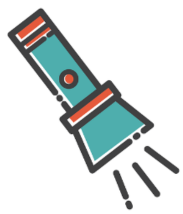
5. Remove the ball from the circle and place the chair with a rope tied around the leg in the center of the circle.
    a. **Ask:** Can the chair move on its own? If (student's name) wants to move the chair across the circle to (student's name) without picking it up, how can s/he do that?
    b. **Note:** In this part of the activity, have students begin by gently pushing the chair across the circle to another student.
    c. **Ask:** What did you need to do to move the chair across the circle to another student? (Responses should indicate an understanding of using the push force to move the chair.)

6. Place the chair back in the center of the circle. Select a student to now move the chair to another student who is in proximity (not across from the student).
    a. **Ask:** How can (student's name) move the chair to (student's name) using the rope that is tied to it?
    b. **Note:** At this point students should be moving to the concept of pull, with the chair being pulled by the student to the other student in the circle. Repeat this process as many times as desired.

7. Discuss with students how they were able to get the chair from one student to another after each one has had a chance to pull the chair to another student. Be sure to talk about pull as a force that moves an object toward something.
    a. **Ask:** What did you need to do to move the chair to another student?

8. Review with students that they were able to use two different forces – push and pull – to move the objects from one student to another in the circle.

Strand One: Explore 2



Remember: This phase provides students with a common base of experiences within which they identify and begin developing concepts, practices, abilities, and skills. Students actively explore the contextual situation through investigations, reading, web searches, and discourse with peers.

Objectives

I can identify the force of push.
I can identify the force of pull.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For the class:

- *Newton and Me* by Lynne Mayer

Preparation

- Read the book ahead of time to be familiar with the content.

Assessment

Student input on the activities of the main character during the read aloud.

Vocabulary

- push
- pull
- force
- motion

Explore 2 Activity

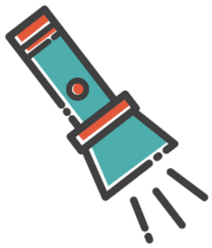
1. Assemble students for a read aloud of the book *Newton and Me* by Lynne Mayer.

2. Begin by reviewing the concepts discussed in the previous session during the Explore 1 activity. Students should remember that objects can be moved using a push and/or a pull.

3. Read *Newton and Me* by Lynne Mayer and ask students to raise their hand when they see or hear a push or pull in the book. For each identified push or pull, talk with students about the force they see and its impact on the object being moved…or not moved.

4. Explain to students that in the next session they will be coming back to the book to review the pushes and pulls they see and hear.

Strand One: Explain



Remember: This phase focuses on developing an explanation for the activities and situations students have been exploring. They verbalize their understanding of the concepts and practices. The teacher introduces formal labels, definitions, and explanations for concepts, practices, skills, and abilities.

Objectives

I can identify when a force is a push, a pull, or both.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For the class:

- **Push, Pull, Both?** poster
- **Quote Cards**

Preparation

- Hang **Push, Pull, Both?** poster for class to see.
- Ensure that **Quote Cards** are in numerical order (see back of each card).

Assessment

Correct responses to the **Push, Pull, Both?** activity

Vocabulary

- push
- pull
- force
- motion

Explain Activity

1. Gather students in an area where they can revisit the read aloud *Newton and Me* while accessing the **Push, Pull, Both?** poster.

2. Explain to students that together you are going to reread *Newton and Me*, but this time you are going to take the time to stop and decide whether the actions in the book represent a push, a pull, or both.

3. Read the book aloud until you reach the first **Quote Cards**.
    a. **Ask:** This **Quote Card** says, "I pulled on my blue jeans, t-shirt and shoes." Is this a push, a pull, or both?
    b. **Note**: Students may answer the question multiple ways – as a group, individually, or as a poll for the correct answer. A student may then hang the **Quote Card** under the correct heading of the **Push, Pull, Both?** poster.

4. Continue reading the book while stopping to identify and then display each of the **Quote Cards** as a push, a pull, or both.

5. Review the poster with students when complete.

Push, Pull, Both?

Push	Pull

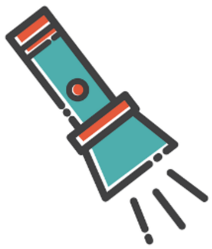
Both

Quote Cards

I pulled on my blue jeans, t-shirt and shoes.	When it was empty it was easy to pull.
I rolled Newton's ball to him.	He pushed while I pulled.
It won't roll at all if I don't give it a push.	The wind at my back pushed me on my way.
I threw the ball hard, it went really high.	The wind pushed against my chest, and I couldn't go as fast.
When I pushed my toy truck, it went really far.	Pedaling uphill was really hard too.
But even my big push won't move my Dad's car.	I pulled, Newton pulled, and then I pulled some more.
We pulled my red wagon.	When he pulled as hard as I did, we didn't move at all.
I couldn't pull it alone.	But when he pulled harder, I'd step forward or fall.

9	1
10	2
11	3
12	4
13	5
14	6
15	7
16	8

Strand One: Elaborate



Remember: This session extends students' conceptual understanding through opportunities for students to apply knowledge, skills, and abilities. Through new experiences, the learners transfer what they have learned and develop broader and deeper understanding of concepts about the contextual situation and refine their skills and abilities.

Objectives

I can investigate how far an empty wagon travels when pushed.
I can identify how adding weight to the wagon impacts the distance traveled.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For the class:

- wagon
- weights
- painter's tape
- **Interval Cards**

For each student:

- **Push Investigation** chart on page 6 in the **Scientist's Notebook**
- writing utensil

Preparation

- Using the 2-foot section of rope and the painter's tape, mark a path that is 10 feet in length from start to finish. Additionally, mark each 2-foot interval with the **Interval Cards** (Begin, 2', 4', 6', 8', End).
- On the board or chart paper, recreate the **Push Investigation** sheet found in the **Scientist's Notebook** on page 6.

Assessment

Students will accurately tally results on the **Push Investigation** chart.

Vocabulary

- push
- pull
- force

Elaborate Activity

1. Gather students around the investigation area with labeled intervals.

2. Explain that students will be conducting an investigation to see how far a wagon travels when pushed.

3. Instruct students to turn to the **Push Investigation** chart in their **Scientist's Notebook**.

4. Model for students how to push the empty wagon from the **Begin** label, determine how far it has traveled, and then record the result on their **Push Investigation** chart and on the class **Push Investigation** chart.

5. Allow each student to take a turn gently pushing the empty wagon while all students tally how far it traveled on their **Push Investigation** chart.

6. Review the group's results on the class **Push Investigation** chart.

7. Return the wagon to the **Begin** label and add the weights to the wagon.

8. Model for students how to push the weight filled wagon from the **Begin** label, determine how far it has traveled, and then record the result on their **Push Investigation** chart and on the class **Push Investigation** chart.
    a. **Note:** Model and review with students how to push with a similar force used when pushing the empty wagon.

9. Allow each student to take a turn gently pushing the weight filled wagon while all students tally how far it traveled on their **Push Investigation** chart.

10. Review the group's results on the class **Push Investigation** chart.
    a. **Ask:** What do we notice about how far the wagon traveled when it was empty versus how far it traveled with weight? Why do you think there's a difference? What do you think we need to do to get the wagon to travel as far with the weight as it did empty?

11. Allow students to experiment with the amount of force needed to make the wagon travel as far with weight as it did empty and/or to travel far enough with weight to cross the end line. This will allow them to feel the amount of push needed to make the weighted wagon travel further.
    a. **Ask**: How did the amount of push you needed to get the weighted wagon to travel further change from the amount of push you needed to move the empty wagon? (Students should be able to articulate that they had to push harder to make the weighted wagon travel as far as the empty wagon.)

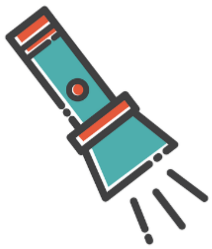
12. Conduct this investigation with a pull instead of a push.
    a. **Ask:** We have been conducting our investigation by pushing the wagon to make it move. How could we investigate the distance traveled using a pull instead? How far do you think the empty wagon would travel with a pull compared to how far it traveled with a push? Which was easier, pushing or pulling the wagon?

Push Investigation

1. How far does the empty wagon travel when pushed?
2. How far does the wagon travel when weight is added, with the same amount of push?

Wagon with Weight					
Empty Wagon					
	0-2 feet	**2-4 feet**	**4-6 feet**	**6-8 feet**	**8-10 feet**

Strand One: Evaluate



Remember: This phase emphasizes students assessing their understanding and abilities and provides opportunities for teachers to evaluate students' understanding of concepts and development of goals identified in learning outcomes.

Objectives

I can design and build a model that demonstrates the applicable force of how objects move with a push and a pull.
I can identify when a push or a pull force is needed.

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.

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Materials

For each student:

- **Evaluation Chart** on page 7 in **Scientist's Notebook**
- **Evaluation Cards** on page 8 in **Scientist's Notebook**
- glue

Preparation

Evaluation Cards could be cut apart before beginning the activity if desired.

Assessment

Students will glue **Evaluation Cards** onto the **Evaluation Chart** to demonstrate understanding of how objects move.

Vocabulary

- push
- pull

Evaluate Activity

1. Direct students to turn to the **Evaluation Chart** on page 7 in their **Scientist's Notebook**.

2. Explain to students that they will be looking at eight different pictures. Some of the pictures show a pull, some of the pictures show a push, and some of the pictures may show both a push and a pull.

3. Give students time to glue the pictures onto the evaluation chart under the correct heading: Push, Pull, Both.
    a. **Note:** The image of the door best represents "both", but could technically be either a push or a pull, depending on whether it is being opened or closed. The image of the street vendor shows both, as he is pushing the cart in front of him and pulling the cart behind him. Other image responses may vary as long as the student is able to justify the response with evidence/reasoning.

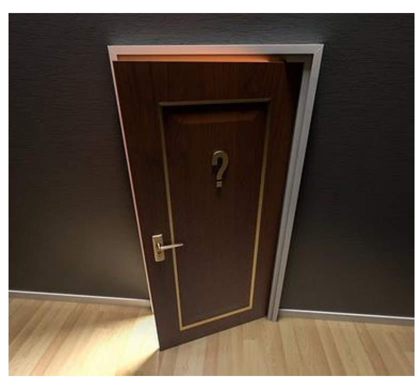
4. Review with students the correct answers after all students have had the chance to complete the chart.

Evaluation Chart

Push	Pull

Both

Evaluation Cards



Engineering Design Challenge Unit Assessment

K. 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.]

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 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 investigations 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)	**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)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1), (K-PS2-2)

Common Core State Standards Connections

ELA/Literacy

RI.K.1 With prompting and support, ask and answer questions about 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 has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

Inquiry Question

What impact does changing the speed or direction of a push or pull have on an object?

Challenge

Students will analyze data to determine the effect of changing the speed and then the direction of different sized marbles on their ability to knock over objects.

Materials

For the class:

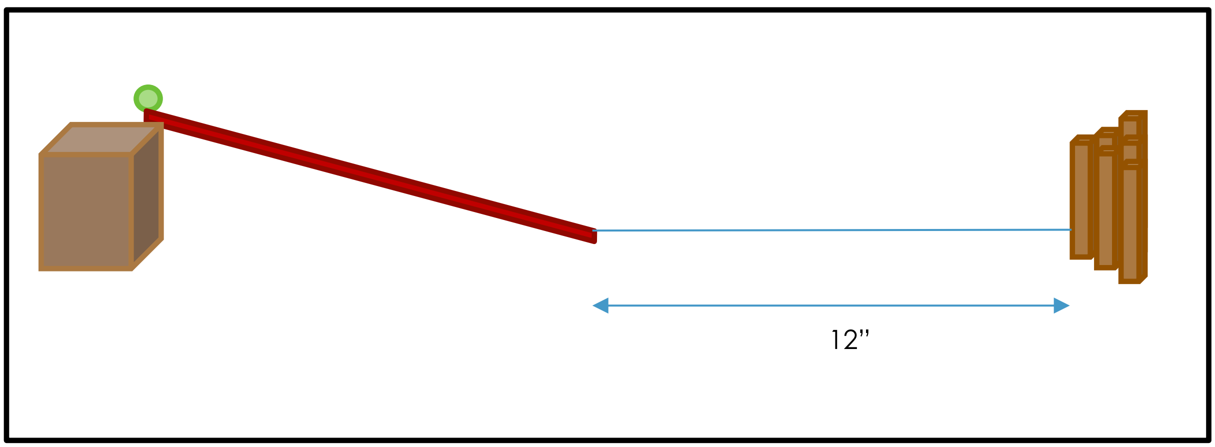
- 4 rulers
- 3 large marbles
- 3 small marbles
- 1 2"x2" block for a ramp base
- 1 2"x3" block for a ramp base
- 1 2"x4" block for a ramp base
- 18 blocks or dominoes
- 4 blocks of modeling clay
- pipe cleaners
- popsicle sticks

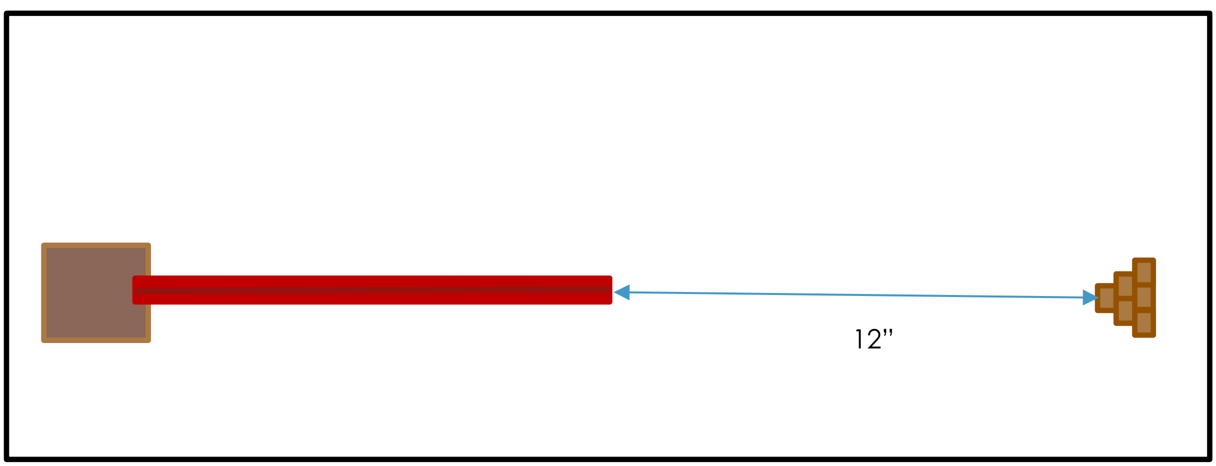
For each student:

- **Tally Sheet**
- writing utensil

Preparation

- Divide 18 wooden blocks or dominoes into 3 groups of 6 blocks each.
- Secure the end of one ruler to each of the wooden bases with tape.
- Set up 3 investigation stations on a single table, each with 6 wooden blocks or dominoes, a wooden base with the ruler taped to it, and 1 small and 1 large marble.
- Mark a line with tape at the end of the ruler that is taped to the ramp base. Measure straight ahead from the tape line one foot and place another piece of tape. Set up the 6 wooden blocks in pyramid format behind this tape line. When complete, the distance from the base of the ruler to the first wooden block should be approximately one foot. (See diagrams below.)
- When finished with Session 1: Ask, leave only the ramp and marble determined to best push the wooden blocks over and remove the others. The remaining ramps and marbles will be used in Session 4: Create.





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Assessment Activities

Session 1: Ask

1. Discuss with students what the different ramps might do to help the different sized marbles push over the blocks.
    a. **Ask**: What do you think will happen to the amount of push the small marble will have on the blocks when we roll it down the lowest ramp? The middle ramp? The highest ramp?
    b. **Ask:** What do you think will happen to the amount of push the large marble will have on the blocks when we roll it down the lowest ramp? The middle ramp? The highest ramp?
    c. **Note:** Students may predict that the push will be greater when rolled from higher. Be sure to highlight the impact speed could play on the push of the marble.

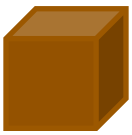
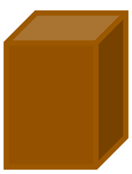
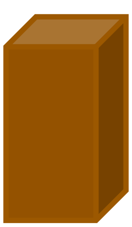
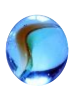
2. Gather students around the investigation stations and explain to them that the class will be conducting trials to collect data about which marbles and ramps create the greatest push on the marble to push over the wooden blocks.

3. Conduct four trails with each marble on each ramp. Students will record how many blocks were pushed over on the **Engineering Design Process: Ask** chart on page 9 in their **Scientist's Notebook**.
    a. **Note:** Trials can be conducted by the teacher or by rotation of students.

4. Discuss with students the patterns they see in the push of each marble depending on the height of the ramp after all trials have been completed.
    a. **Ask:** Which combination of marble and ramp caused the most number of blocks to be pushed over? Why do you think this is?

Engineering Design Process: Ask

How Many Blocks Were Pushed Over?

Trial		First	Second	Third	Fourth
					
					
					
					
					
					

Session 2: Imagine

1. Review the inquiry question with students in their **Scientist's Notebook** on page 10. Talk about the results of the investigation from Session 1: Ask.
    a. **Ask:** In Session 1: Ask, we investigated the impact the push of a marble had on the number of blocks it was able to push over and determined which ramp and marble knocked down the most blocks. Now we are going to think about what might happen if we move the ramp so that it is not directly in front of the blocks. What can we do to change the direction of the marble so that it can still push over the blocks?
    b. **Note:** The ramp stays at a fixed position; it cannot be directed toward the blocks.

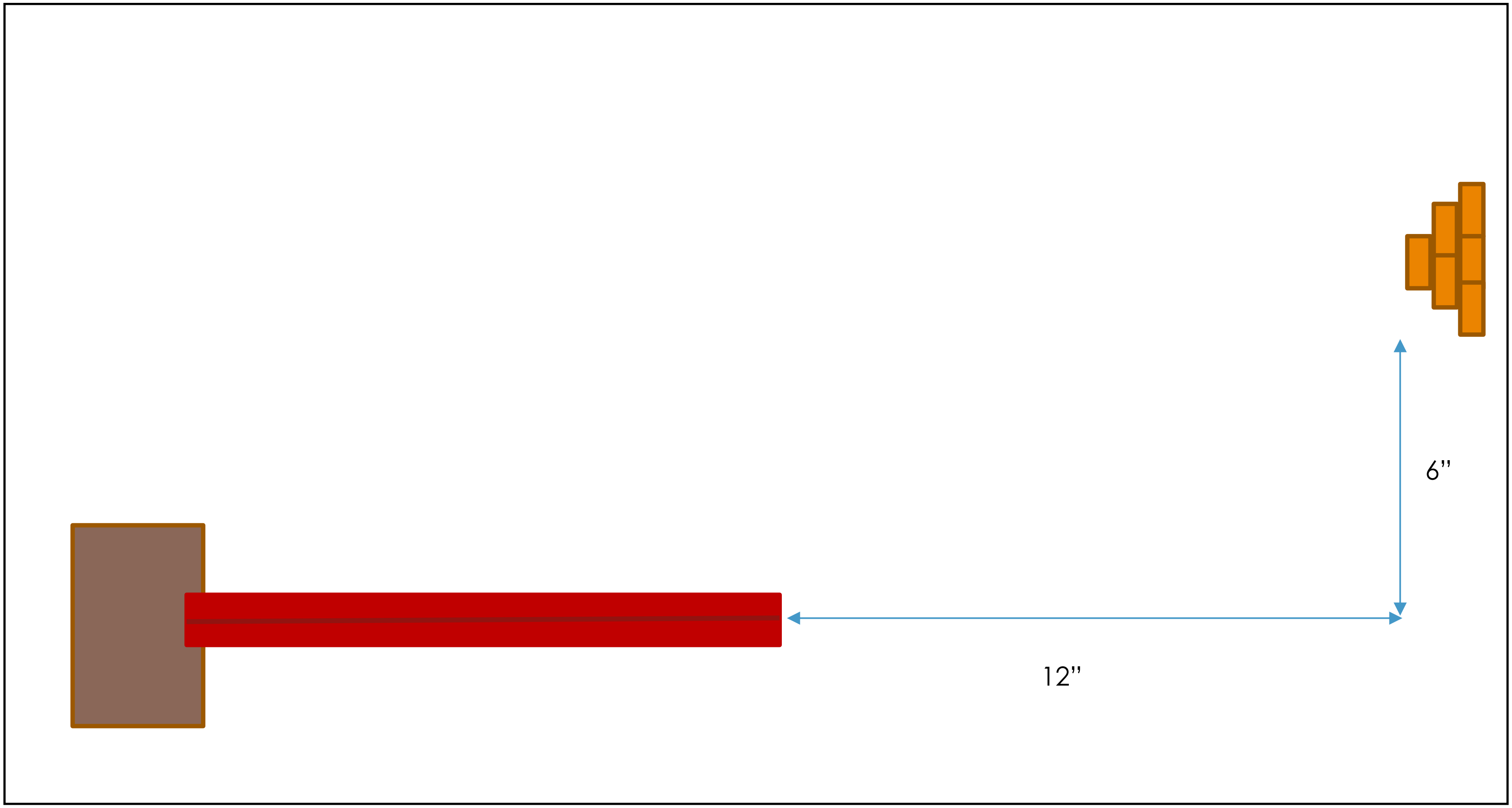
2. Explain to students that they are going to think about what they can do to turn the marble so that it can still push over the blocks.

3. Display the different items they might be able to use to turn the marble, including modeling clay, popsicle sticks, pipe cleaners, other wooden blocks, tape, etc. Additional materials can be displayed at the teacher's discretion.

4. Pair students and have them share ideas with each other.

5. Ask each pair to design a solution that will push over the greatest number of blocks when the ramp is moved so that it is not directly in front of the blocks. Using the **Engineering Design Process: Imagine** sheet on page 10 in their **Scientist's Notebook**, ask students to imagine and then draw what materials will best work to change the direction of the marble so that it will push down the greatest number of wooden blocks.

<u>**Engineering Design Process: Imagine**</u>



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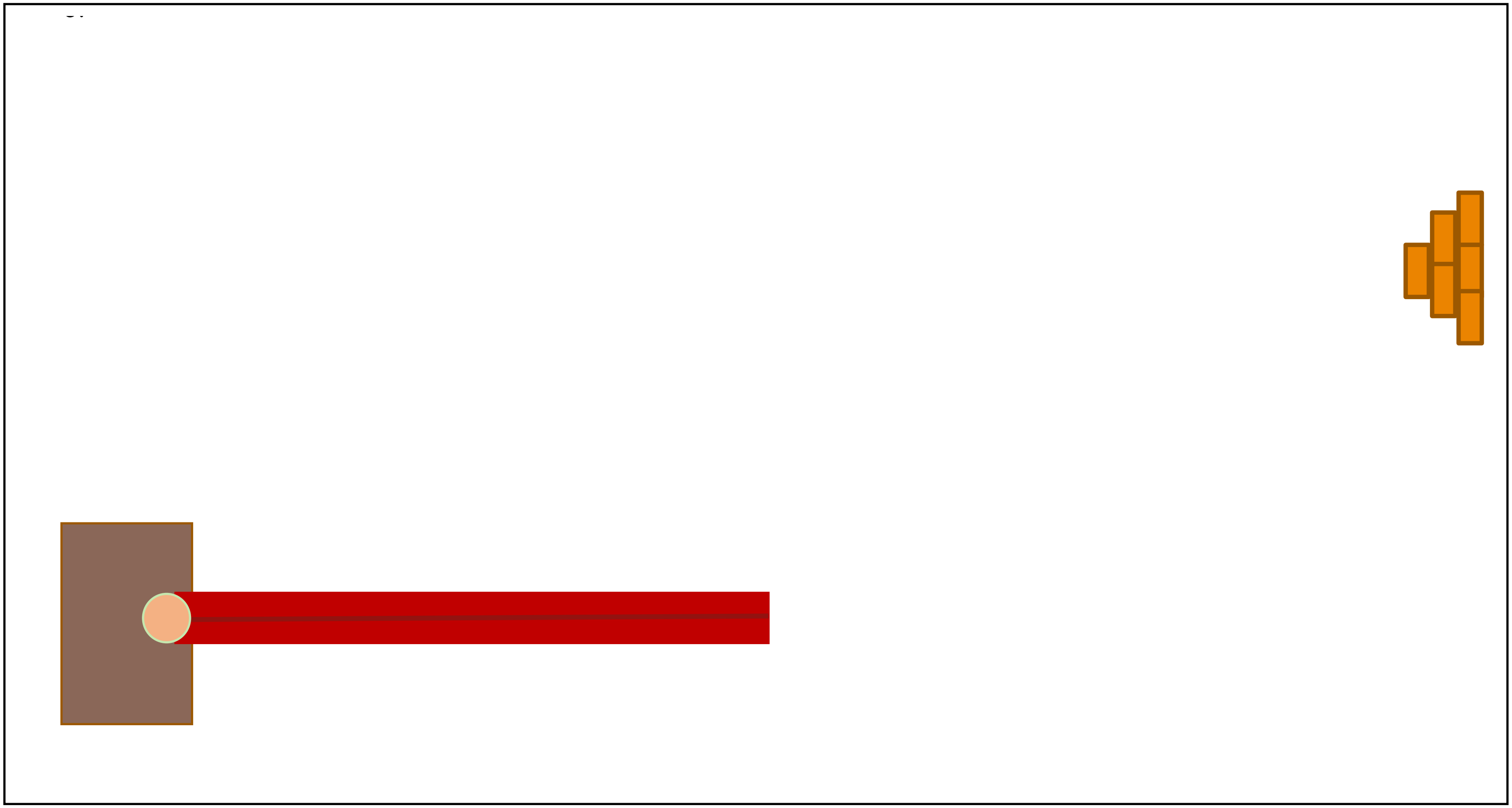
Session 3: Plan

1. Ask students to review their ideas for changing the direction of the marble on the **Engineering Design Process: Plan** sheet on page 10 in their **Scientist's Notebook**.
    a. **Ask:** Think about the drawing you created for your idea to change the direction of the marble so it will push over the wooden blocks. What materials will you need? How will you set them up?

2. Allow students time to plan their solution by working with the items they have decided to use to turn the marble.
    a. **Note:** Students may decide to try a different solution than the one they have drawn as they experiment with the materials. This would also be the time to try out multiple solutions if created during Session 2: Imagine.

<u>**Engineering Design Process: Plan**</u>



<u>Session 4: Create</u>

1. Remind students they have planned a design solution that will change the direction the marble when rolled down the ramp and allow it to push over the wooden blocks.

2. Gather students around the investigation station and explain that they will now be testing their final design solutions and recording their findings on the sheet **Engineering Design Process: Create** on page 11 in their **Scientist's Notebook**.

3. Allow student pairs to take turns setting up and testing their design solution to make the marble turn and push over the blocks.
    a. **Note:** Remind student pairs to record their findings on the sheet **Engineering Design Process: Create** on page 11 in their **Scientist's Notebook**.

4. Tell students that in the next session they will be reviewing their findings from today's investigations.

Engineering Design Process: Create

Did the marble hit the wooden blocks?

Yes No

How many blocks were pushed over?

1 2 3 4 5 6

Do you need to improve your solution?

Yes No

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Session 5: Improve

1. Remind the class that in Session 4: Create, each student pair had a chance to test their design solution. Discuss what was learned as a group.
    a. **Ask:** What did you discover about your design solutions and their ability to change the direction of the marble so it would push over the blocks?

2. Ask students what changes they would like to make to improve their design solution. Give each student pair a chance to answer.
    a. **Ask**: Now that you have had the chance to see each of the design solutions, would you like to make changes to your design solution? What kind of changes would you make? Why?

3. Time permitting, allow students to investigate how changing their design solution might impact their result by allowing each pair to re-test their new design and record their findings.

Engineering Design Challenge Rubric: Teacher Friendly

Student will be able to…	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
identify and implement each step of the Engineering Design Process.	Student does not successfully implement any steps of the Engineering Design Process.	Student implements at least some of the Engineering Design Process. Some aspects of implementation are missing, incomplete, or incorrect.	Student independently, correctly, and completely implements all five steps of the Engineering Design Process	Student participates at proficient level and goes significantly beyond (i.e., by being appropriately flexible in their use of the Engineering Design Process).
use their background and content knowledge gained earlier in the unit to inform their designs.	Student does not successfully use knowledge gained earlier in the unit to inform their design.	Student partially or incorrectly draws on prior knowledge to inform their design.	Student correctly and routinely uses prior knowledge to inform their design.	Student goes significantly beyond proficient level (i.e., by identifying relevant questions for further investigation).
evaluate their design using established criteria and use their evaluation to inform improvements.	Student does not successfully evaluate their designs using established criteria.	Student evaluates a design and makes improvements. Evaluation is incomplete or not used to inform improvements, or student requires significant support.	Student completely and accurately evaluates designs using established criteria. Evaluation is used to inform improvements.	Student participates at proficient level and goes significantly beyond (i.e., by evaluating their new design and discussing further improvements).
discuss, communicate, collaborate, and share solutions with others.	Presentation includes contributions unequally from all team members. Most team members were often off task and not cooperating or participating fully. Presentation is communicated and covers most or a few aspects of the design process.	Presentation includes contribution from some members. Team members were occasionally off task and needed prompting. Presentation is somewhat clearly communicated and covers all or most of the design process.	Presentation includes contributions from all team members. Team members needed little prompting to stay on task, work well together, and contribute equally. Presentation is somewhat clearly communicated and covers all or most of the design process.	Presentation includes contributions from all team members. All team members worked well together, participated, and stayed on task without prompting. Presentation is clearly communicated with appropriate data, sketches, graphs, and/or pictures and covers all areas of the design process.

Engineering Design Challenge Rubric: Student Friendly

Student will be able to…	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
Engineering Design Process	Engineering Design Process (Ask, Imagine, Plan, Create, Improve) was not followed.	Some of the Engineering Design Process was followed.	All five steps of the Engineering Design Process were followed.	The Engineering Design Process was used many times and was flexible.
Session Knowledge	Knowledge from sessions was not used to create the design.	Little knowledge from sessions was used or was incorrect to create the design.	Knowledge from sessions was used correctly to create the design.	Knowledge from sessions was used correctly and further research was done to create the design.
Criteria and Improvements	Design does not follow criteria or a form of improvement.	Design does not follow all of the criteria, or the improvements are very small.	Design follows all criteria and shows improvement.	Design follows all criteria and shows many forms of improvement.
Collaboration	Team members did not work well together. The presentation is missing some of the information.	Team members needed reminded to stay on task. Most of the information is included with the presentation.	Team members shared working together. Little reminding was needed to stay on task. Presentation is complete.	Team members shared working together without teacher reminders. Presentation is complete with added material.

Glossary

force	what makes something move
motion	the direction of movement
pull	to bring toward
push	to move away