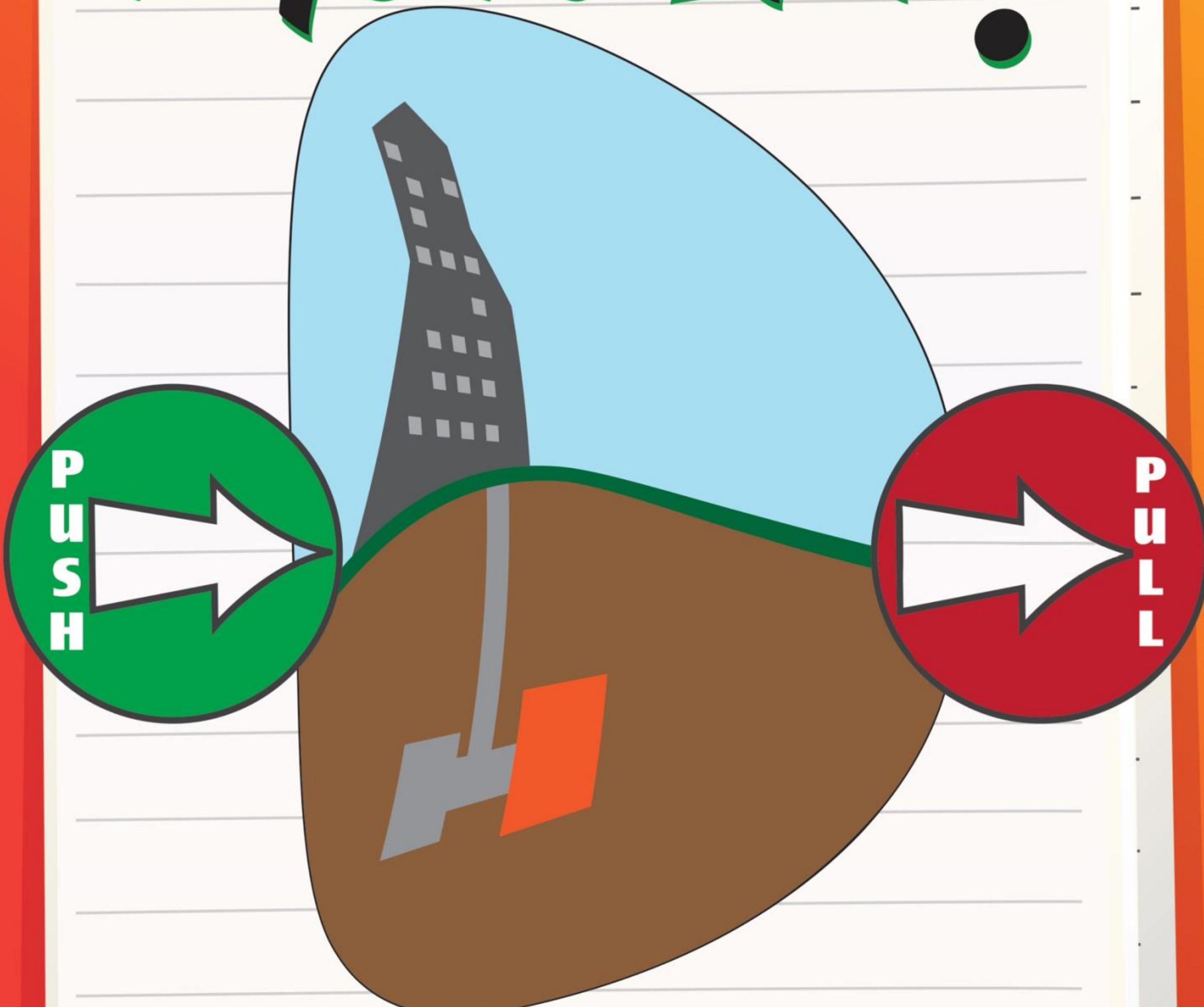
# Move It!




Education and Outreach

**K-2 Curriculum Unit**

# Move It!

"Forces and Motion"

Science Focus: Using cause and effect to explore ideas about motion

| Lesson # | Lesson Title | Suggested Time |
|---|---|---|
| **1** | Push and Pull Forces<br>Move It | 40 minutes |
| **2** | Balanced and Unbalanced Forces<br>This Means War | 30 minutes- part 1<br>50 minutes- part 2 |
| **3** | Fast and Slow Motion<br>Going the Distance | 30 minutes- part 1<br>40 minutes- part 2 |
| **4** | Altering Speed and Direction<br>A Change of Plans | 40 minutes- part 1<br>50 minutes- part 2 |
| **5** | Putting it All Together<br>Engineering a Solution<br>Forces at Work | 40 minutes- part 1<br>40 minutes- part 2<br>30 minutes- part 3 |

**Move It! - Grades K-2 (Physical Science)**

During this unit students will explore the motion of objects and manipulate the forces required to control that motion. Students also analyze data from tests of two objects designed to solve the same problem to compare strengths and weaknesses of how each performs. As this unit comes to a close, students will examine push and pull forces at work at the Sanford Underground Research Facility.

# Move It!

## Forces and Motion

Every day we cause things to move. Opening a door, pulling out a chair, closing a book, or kicking a ball – each requires just the right push or pull – but how much do we think about these actions?

It is likely that your students have pulled open a drawer to get some socks, pushed the drawer closed, pulled a box of cereal from a cupboard, and pushed a foot into a shoe without considering either forces or motion. These everyday experiences (and countless others) can help students gain a deeper understanding of these concepts by examining how and why different objects move.

When students pick up their backpack they know that it takes strength to pull it up. They also know that some days the backpack is heavier and it takes more effort. In short, sometimes more force is required to cause an object to move.

Early learners have discovered that different strengths of pushes or pulls will give them different results in terms of an object's distance, speed, or direction of motion. During this unit students will explore and manipulate the motion of objects and the forces required to control that motion. This will help them understand that pushing or pulling can change the position and motion of objects, and that the size of the change is related to the strength of the force and the weight of the object to be moved.

While students may not be able to "see" that forces are at work on everything. This unit provides a series of experiences designed to deepen student thinking about motion and its causes. Students will learn how the movement of objects can be described, and even predicted, because no matter what is moving it will always start, stop, or change direction according to certain rules.

# Move It!

## *Standards Addressed in the Unit*

**K-PS2-1** Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

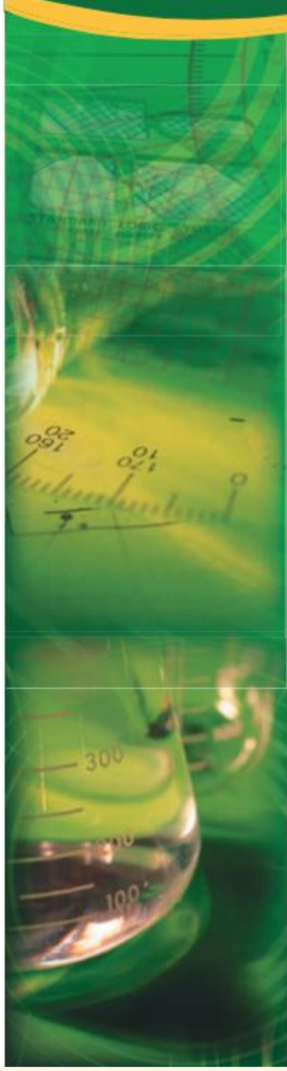
**K-PS2-2** Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or pull.*

**K-2-ETS1-3** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

*Standards with an emphasis on engineering are marked by an asterisk (*).*

*For more information on Engineering, see the Framework page 201 and Appendix C of the South Dakota Science Standards.*

# Science and Engineering Practices



1. Asking questions (science) and defining problems (engineering).
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematics and computational thinking.
6. Constructing explanations (science) and designing solutions (engineering).
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information.

*A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2011)

# Move It!

## Materials List

- **Teacher-Provided**

| Lesson | Materials Needed |
|---|---|
| 1 | *For each student:*<br>➢ Science notebook<br>*For the teacher:*<br>• *Video- Mini Golf Physics*<br>➢ Chart paper and markers (or whiteboard)<br>• Golf ball<br>*For each pair/small group:*<br>• *Push, Pull, Sort* cards |
| 2 | *For each student:*<br>➢ Science notebook<br>*For the teacher:*<br>• Book- *Equal Shmequal* by Virginia Kroll<br>➢ Chart paper and markers (or whiteboard)<br>• *Tug of War* animal strips<br>• Scenario cards<br>• *Video- Mini Golf Physics*<br>*For each pair/small group:*<br>• *Tug of War* animal strips |
| 3 | *For each student:*<br>➢ Science notebook<br>*For the teacher:*<br>➢ Chart paper and markers (or whiteboard)<br>• Wooden car (part 1)<br>• *Video- Mini Golf Physics*<br>*Part 1 (distance)--For each pair/small group:*<br>• Bean bags- number line- tape- marking shapes<br>*Part 2 (speed)--For each pair/small group:*<br>• Toy cars- tracks- tape<br>➢ Books or blocks |

| | |
|---|---|
| 4 | *For each student:*<br>➢ Science notebook<br>*For the teacher:*<br>➢ Chart paper and markers (or whiteboard)<br>• Toy car- track- books or blocks (part 1)<br>• Tennis ball (part 2)<br>• Book- *Sheep in a Jeep* by Nancy Shaw<br>• *Video- Mini Golf Physics*<br>*Part 1 (changing speed)--For each pair/small group:*<br>• Toy cars- tracks- books or blocks- tape- various test objects<br>*Part 2 (changing direction)--For each pair/small group:*<br>• Tennis balls- wiffle balls- ping pong balls -racquet balls |
| 5 | *For each student:*<br>➢ Science notebook<br>*For the teacher:*<br>➢ Chart paper and markers (or whiteboard)<br>• *Video- Mini Golf Physics*<br>• Forces at work pictures (Sanford Underground Research Facility)<br>*For each pair/small group:*<br>• Paddle ball<br>• Bungee ball |

## Adjusting Modules to Accommodate Your Classroom Needs

### Timing

The education team at the Sanford Underground Research Facility has done its best to develop curriculum modules that are flexible and incorporate both facilitator and student supports. As you explore this module with your students, please keep in mind that these curriculum modules are grade banded. If your students are at the lower end of the grade band, or if they come to you with limited experiences in science, you should fully expect the module to take more time than designated in the facilitator's guide. This is especially true if you teach very young students.

As an effective educator, you will know how to adjust the timing of these lessons to best fit your classroom and students. Please feel free to break any of the lessons into shorter segments, over multiple days, to accommodate the learners in your classroom.

### Follow-up/Practice

Lessons in this unit include 'Follow-up/Practice' sections. These are useful (optional) resources proposed to enrich classroom practices for diverse learners. These resources are not included in the time designations of the unit; if you feel your students will benefit by pursuing these resources, please plan for additional time.

### Design Principles

Effective educators alter, adjust, and change their instruction depending on who is in the classroom and the extent to which those students are succeeding. Frequently, educators will augment curriculum with additions of instructional strategies. However, please keep in mind that best practices in science education have shifted from merely *learning about* to *figuring out.* These units are designed to provide opportunities for students to figure out phenomena and design solutions to problems.

This emphasis on *figuring out* represents a revolution in how we teach science at all grade levels. In their learning, students must use all three dimensions of the science standards—crosscutting concepts (CCCs), disciplinary core ideas (DCIs), and science and engineering practices (SEPs)—in an integrated fashion to make sense of phenomena or design solutions to problems.

Classrooms incorporating three-dimensional learning will have students build models, design investigations, share ideas, develop explanations, and argue using evidence. All of which allow students to develop important 21st century skills such as problem solving, critical thinking, communication, collaboration, and self-management. Three-dimensional learning also helps students apply new knowledge to other situations. Every student will benefit from this instructional approach.

| Important Notes | |
|---|---|
| Science Notebooks | **You may wish to have students set up their Science Notebooks prior to the first lesson.**<br>Science notebooks are an important part of solidifying your students' learning. Student scientists record their observations, questions, evidence, and ideas in a running record of their thinking. Science notebooks are also a great way to practice writing skills!<br><br>As students develop their understanding of science concepts, they may use drawings and other illustrations- such as charts, tables, models, and graphs. The science notebook can be used by the teacher to assess the development of student understanding.<br><br>Science notebooks may be a printed booklet prepared by the teacher, a bound composition, or a spiral notebook. A printable science notebook specific to this unit is available. *There is a word bank page to assist emerging writers. |
| Developing Scientific Language | Developing scientific language is important, however introducing all the scientific terminology before students learn about the concepts they are connected to is not recommended.<br><br>As they are first learning, students should communicate about and grapple with phenomena using their own words. Once they begin to develop a firm conceptual understanding of an idea, then introducing the relevant scientific term(s) provides students with the scientific language they need to communicate and discuss their thinking with others more clearly.<br><br>As the unit builds, there are intentional and purposeful opportunities for students to practice using their 'new' scientific terminology in an authentic context.<br><br>Cards for word charts and word walls, specific to this unit are available on the unit USB. |
| Student Responses | This facilitator's guide contains examples of possible student responses to discussion questions and activity sheets. These examples are not intended to be prescriptive but are imagined as helpful resources for educators as they uncover student thinking about the concepts in the unit. |

| Lesson 1 | Move It |
| --- | --- |
| Overview Standard(s) & Objectives | **Overview**<br>To start the lesson, students watch a short video of a golf ball on a mini course. Through experimentation, observation, and class discussion students will determine that to cause an object to move a force (a push or pull) is needed. They will learn that pushes and pulls are forces in a particular direction.<br><br>**Building Toward**<br>**K-PS2-1** Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.<br><br>Crosscutting Concept<br>• Cause and Effect- Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes.<br><br>Science and Engineering Practice<br>• Planning and Carrying Out investigations- with guidance plan and conduct an investigation in collaboration with peers.<br><br>**Objectives**<br>Students<br>• Recognize that to cause an object to move a force (a push or pull) is needed.<br>• Differentiate between push and pull forces.<br>• Describe the direction of pushes and pulls. (away, toward)<br>• Explain that the movement of an object is caused by a force that is either a push or a pull in a particular direction.<br>• Use cause and effect to explain how push or pull forces affect the motion of objects. |
| Background Information | **Motion**<br>Motion is the movement of an object from one position to another. Motion always occurs along a continuous path. Moving objects do not jump from one place to another without traveling through all of the intermediate points. Motion is a key characteristic of all matter that can be observed, described, and measured.<br><br>**Forces (Pushes and Pulls)**<br>When an object starts moving there is evidence that a force has acted on it. This movement is caused by a force that is either a push or a pull in a particular direction. Push and pull are opposite forces, meaning they move objects in different directions. A push causes an object to move away, while a pull causes an object to move toward. |

| | |
|---|---|
| Materials | *For each student:*<br>• Science notebook (if using, word bank page to assist emerging writers)<br>*For the teacher:*<br>• *Video- Mini Golf Physics*<br>• Chart paper and markers (or whiteboard)<br>• Golf ball<br>*For each pair/small group:*<br>• *Push, Pull, Sort* cards |
| Prior Knowledge | Students should understand "push" and "pull."<br>Students should have the ability to recognize movement/motion.<br>Students should be able to describe the motion of an object using directional words (in, out, left, right, up, down) and positional words (above, below, beside, in front of, behind) **See idea for practice at end of lesson**<br>**Suggestions for practice sheets can be found at** https://www.sightwordsgame.com/directional-positional-words/ |
| Questions | **Driving Question**<br>• What makes an object move?<br>**Probing Questions**<br>• How do you know when something is moving (has motion)?<br>• What causes an object to move?<br>• What are some things that can be moved with a push? A Pull?<br>• How can we describe the direction of pushes and pulls? (away, toward)<br>• How would you describe something that isn't moving?<br>• What would an object at rest do if no forces were acting on it?<br>• Can objects move on their own? What is needed? |
| Launch (15 minutes) | |
| Engagement and Communication of Student Expectations | Tell students that this lesson is going to be all about what causes objects to move.<br>Prior to viewing the launch video, elicit students' prior knowledge about a game called mini golf.<br>• What is the goal? *(To get the ball in the hole using the least number of strokes. Every time the putter touches the ball, that counts as one stroke.)*<br>• What equipment is needed? *(Only a putter and a golf ball- pencil and paper if you are keeping score)*<br>Let students know they will be watching a video. They should be prepared to share what they noticed and what they wondered about the ball in the video.<br>Show the video, **Mini Golf Physics** (first 30 seconds only) to students. On USB or https://www.yout-ube.com/watch?v=GygGhvcAaPw (may wish show twice)<br>*The facilitator should act as recorder. Keep a record of student ideas on chart paper or the whiteboard.* |

| | |
|---|---|
| <br> | Ask students to turn and talk to a partner about the ball in the video clip.<br>• What did you notice? (*It is red. At first it wasn't moving. It went a long way. It was in many places. At the end it stopped in the cup, etc.)*<br>• What do you wonder? (Who hit the ball? Where is this? *What keeps it going? How far did it go? Was it all the same ball? How does it go different directions?)*<br><br>Ask a few students to share what they noticed/wondered about the golf ball.<br><br>Tell your students that you have a question about mini golf.<br>• What caused the golf ball to start moving?<br><br>*Likely responses include the putter, or the player. This is an opportunity to hear what students are thinking. Accept all answers, but then ask, "What made 'that' move?"*<br><br>If students insist the player caused the ball to move. Place a golf ball on a level surface. Challenge the class to move the ball with their minds. No matter how much we want an object to move, something more than a wish must happen.<br><br>Did a person touch the ball in the video?<br><br>If they did not touch the ball, how could they make it move? |
| Explore (10 minutes) | |
| Procedure | Share with the class that explaining what causes something to move is challenging. This is definitely something we need to explore more! Let's start with thinking about everyday objects.<br>1. Ask one student to move a chair a short distance. (**Setup**-make sure to start with a chair that is in a situation that will require the student to pull it out/**away** from desk/table)<br>2. Ask another student to move it back. (*They will push it in* ***toward*** *the table/desk*)<br>3. As a class discuss what happened. (i.e., *the chair was pulled* ***out****/the chair was pushed back* ***in****).*<br>4. *What are other direction words? (left, right, up, down, forward, backward*)<br>5. Ask the class to select another object in the classroom to move. (*Discuss…these objects cannot move by themselves. They need a* ***force****- a push or a pull to move a particular direction*)<br>6. Working as partners, students will identify objects (many) in the room that they could move (a short distance) with a force that is a **push** or a **pull**. (e.g., *door, pencil box, drawer, toy, light switch, window, book*)<br>7. Record these ideas in your science notebook.<br>8. With permission from the teacher, partners should move one object. One partner will use a push, the other will use a pull. (e.g., pull *a book from the shelf, use a push to return it or turn a light switch on, then off*) |

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9. In their science notebook, students will draw a picture of themselves moving the object. They will draw an arrow to show the direction the object moved. Then identify if they used a push or a pull force to cause the object to move.
10. Switch partners. Share your drawing with another student. Discuss the object that was moved, its direction, and whether a push or a pull force was used.

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<tr><td colspan="2">Summarize (15 minutes)</td></tr>
<tr><td>Communicate</td><td>

**Group Discussion**

Facilitate a class discussion. Remember to allow a few moments of personal think time before asking students to share their thinking aloud. Pose only one question at a time.

- How do we know when something is moving?

  *Allow 3-5 seconds of <u>personal think time</u> before accepting student ideas.

  (Student *responses may vary but should convey the idea of a change in physical position*) It started next to_____ , but now it's ______ .

Explain that when something moves scientists call this **motion**.

- What causes an object to move?

  *Allow 3-5 seconds of <u>personal think time</u> before accepting student ideas.

  *(Objects cannot move by themselves. They need a force- a push or a pull)*

- What are some things that can be moved with a push?

  *(write/sketch ideas on board)*

- What are some things that can be moved with a pull?

  *(write/sketch ideas on board)*

*(Students may decide that some of the ideas could be instances of either- for example, opening or closing a door… students should be able to explain their reasoning)*

Introduce PUSH hand motions and say together: "When I PUSH an object, it moves AWAY."

With feedback from students, draw an arrow on some of the examples above to show the direction of the push.

Introduce PULL hand motions and say together: "When I PULL an object, it moves TOWARD."

With feedback from students, draw an arrow on some of the examples above to show the direction of the pull.

- How can we describe an object that isn't moving? It can move, but is not moving right now. (*unmoving*, *still, at rest, stationary, stopped…*)
- What would an object at rest do if no forces were acting on it? (*no change*)

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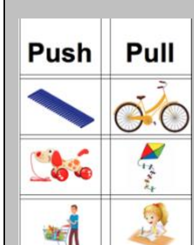
| | • What is the effect of a push or pull? (it's what happens as a result of the push or pull) Example? (when I pull an object-cause)(it moves away-effect)<br>• Can objects move on their own? (*No*) What is needed? (*a force- push or pull*)<br>If student(s) say yes… Ask, "What is one example?" (Students may mention ramps or slopes. If so, let them know that there will be an opportunity to explore soon!)<br>*****Common naïve conception****: Students may think force is a property of an object. They may think that the object stops moving when the force inside it "wears off" or "runs out." But forces act upon objects; they are not parts of those objects.*<br>Let's circle back to the beginning.<br>• What caused the golf ball to move? (*a push from the putter*)<br>• Which direction did the ball move? *(effect) (away from the putter)*<br>Complete these sentence frames in your science notebook- or as a class.<br>A (*force*) is a push or pull on an **object**.<br>The (*putter*) caused the **golf ball** to move (*away*). The **force** was a (*push*). |
| Terminology and Concepts to Solidify | **Cause-** to make something happen<br>**Direction-** the way something moves or faces<br>**Effect-** what happens because of a cause<br>**Force**- a push or pull on an object<br>**Motion**- a change in position<br>**Object**- a thing that can be seen and touched<br>**Position-** where an object is in relation to something<br>**Push**- a force that moves an object away<br>**Pull**- a force that moves an object toward |
| Connection to Big Ideas (Phenomena) | When an object moves there is evidence that a force has acted on it.<br>The movement of an object is caused by a force that is either a push or a pull in a particular direction. |
| Follow Up/Practice<br> | **Partner with the PE teacher to create a Mini Golf course**<br>https://www.ssww.com/blog/mini-golf-lesson-for-physical-education/<br>**The Great Laundry Basket Race**<br>Students pair up and make predictions on how many seconds it will take them to push (and pull) their friends across the carpet!<br>https://www.yout-ube.com/watch?v=Qk6nYekPOQI<br>**Push, Pull, Sort**<br>Sort the cards into two groups. Those that represent a push, those that represent a pull.<br>Compare with another group. Students must be able to defend their thinking when explaining why they placed each card in a certain group.<br>Encourage students to add their own examples of push and pull. |

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**Push Pull Scavenger Hunt**
Show the students two different colored sticky notes. Tell them that one color is going to stand for push (pink for example), and one will stand for pull. Make sure to clarify that there are several objects that can be pushed or pulled, so it’s ok if there is more than one color sticky note on an object.

Students should work with a partner to go around the room and attach a colored sticky note to anything they push, and then do the same for anything they pull with the other color notes. (Provide the students with enough time to label as many different things as possible.)

After students have returned to their seats, review where all the notes have been placed. Some of the students can volunteer where they placed their notes and why they thought the note was appropriate. During this time the teacher should include a class discussion of any sticky notes that seem out of place.

Ask the students how their lives would be different if we did not push or pull these things. What would we no longer be able to do? Explain that by applying force upon these objects, we are able to move things around us.

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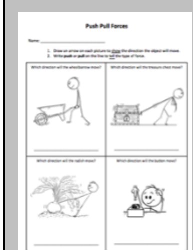
Assessment



Push Pull Forces

Cause and Effect

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**The teacher will use student notebooks, discussions, and observations of students to assess progress and understanding of concepts.**

(Example) You may use the science notebook page of the student moving an object.

- Correctly identified direction of movement?
- Correctly identified force used- push or pull?

**Push Pull Forces**

- Draw an arrow on each picture to <u>show</u> the direction the object will move.
- Write **push** or **pull** on the line to <u>tell</u> the type of force.
    - Form B allows students to circle choice.

**Sentence Frames**
Students use sentence frames to explain the motion of objects using cause and effect statements. (verbally or in writing)

The (<u>*kick*</u>) caused the **soccer ball** to move (<u>*away*</u>). The force was a (<u>*push*</u>).

The (<u>*rope*</u>) caused the **bucket** to move (<u>*toward*</u>). The force was a (<u>*pull*</u>).

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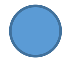
# Cause and Effect

| If you… | (Cause) | object | (Effect) |
|---|---|---|---|
|  kick a ball | (Push) |  the ball | (moves away) |
| | | | |
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## Prior knowledge (suggestion for practice)

Students should be able to describe the motion of an object using directional words (in, out, left, right, up, down) and positional words (above, below, beside, in front of, behind)

Simon says - Sit on the floor and put your pencil……

| | | |
|---|---|---|
| in front of you | close to you | on your left |
| behind you | far from you | on your right |
| above you | between your hands | pointed up |
| below you | on top of your feet | pointed down |
| on you | | |
| under you | | push away |
| over you | | pull toward |

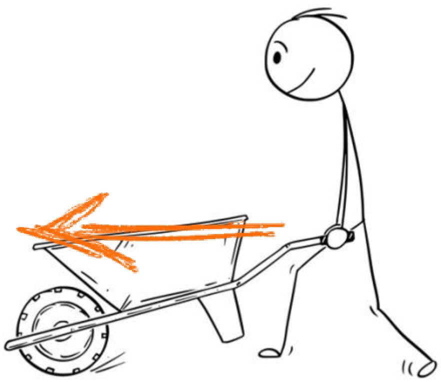
*Students who are not familiar with any of these terms may need to be assisted by the teacher or learn by observing their friends.

# Push Pull Forces

Name Your Student

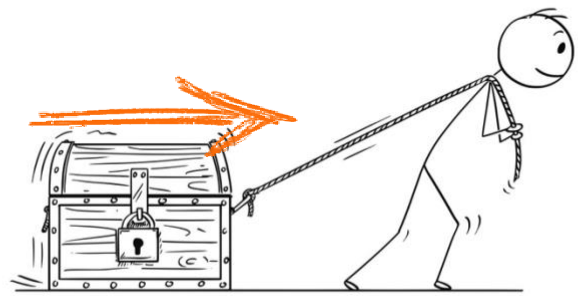
1. Draw an arrow on each picture to <u>show</u> the direction the object will move.
2. Write **push** or **pull** on the line to <u>tell</u> the type of force.

Which direction will the **wheelbarrow** move?



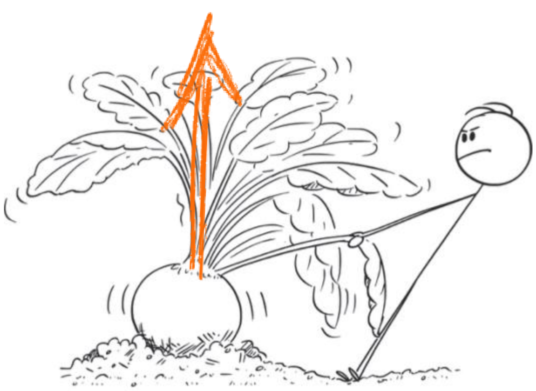
Push

Which direction will the **treasure chest** move?



Pull

Which direction will the **radish** move?



Pull

Which direction will the **button** move?

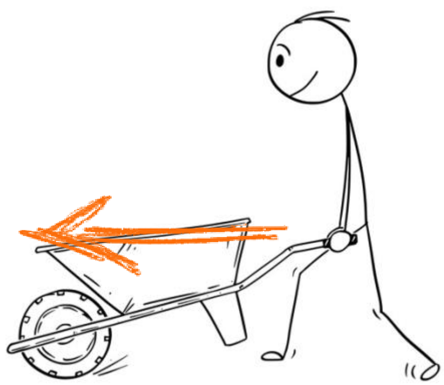
Push

# Push Pull Forces

Name ____Your Student________

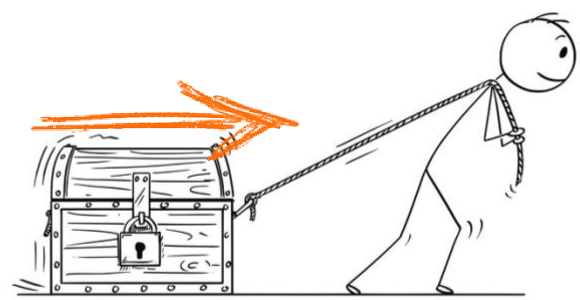
1. Draw an arrow on each picture to <u>show</u> the direction the object will move.
2. Circle either **push** or **pull** to <u>tell</u> the type of force.

Which direction will the **wheelbarrow** move?



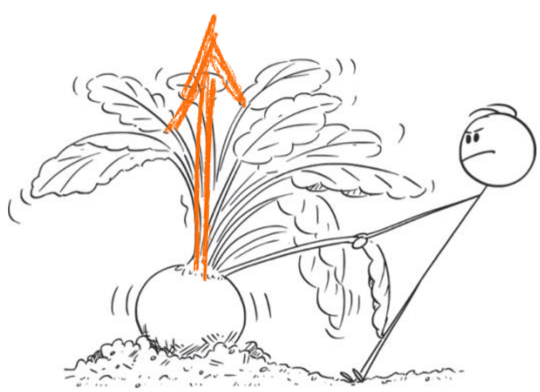
**Push** **Pull**

Which direction will the **treasure chest** move?



**Push** **Pull**

Which direction will the **radish** move?



**Push** **Pull**

Which direction will the **button** move?

**Push** **Pull**

<table>
<tr><th>Lesson 2</th><th>This Means War</th></tr>
<tr><td>Overview<br>Standard(s) &<br>Objectives</td><td>Overview<br>During this lesson, students develop an understanding of what “equal” means and are introduced to the concept of balanced and unbalanced forces. Students determine that how easily an object moves (or doesn’t) depends on its weight and the strength of forces acting upon it.<br><br>Building Toward<br>K-PS2-1 Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.<br>Crosscutting Concept<ul><li>Scale, Proportion, and Quantity- Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower)</li><li>Stability and Change- Some things stay the same while other things change. Things may change slowly or rapidly.</li></ul>Science and Engineering Practice<ul><li>Developing and Using Models- Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).</li></ul>Objectives<br>Students<ul><li>Recognize that more than one force can act on an object at the same time.</li><li>Model balanced and unbalanced forces. (equal- not equal)</li><li>Explain that some objects are easy to move while other objects are difficult to move.</li><li>Explain that to move heavy objects, greater force is needed.</li><li>Explain that to move light objects, less force is needed.</li></ul></td></tr>
<tr><td>Background<br>Information</td><td>Balanced and Unbalanced Forces<br>Balanced forces are forces in <u>opposite directions</u> that are “equal” in strength. This means the effect of one force is cancelled out by its opposite equal force. In a game of tug of war each team pulling equally on the rope is an example of balanced forces. Balanced forces are responsible for the “unchanging” motion of the midpoint of the rope.<br><br>When forces acting on an object are not equal in strength, they are called unbalanced forces. During a game of tug of war, if players on one side of the rope pull harder (with more force) than those on the other side, the midpoint of the rope changes and will move toward the side applying the greater force. The team that pulls with the most force will win the game.</td></tr>
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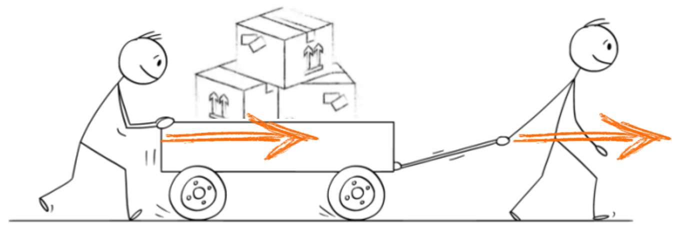
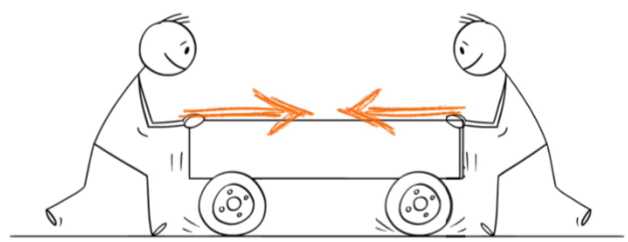
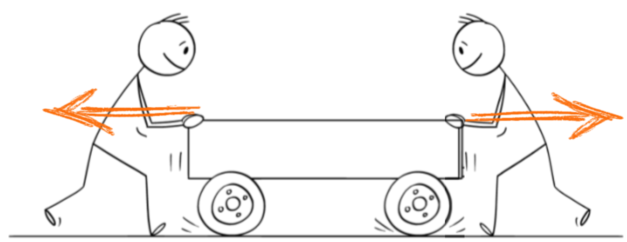
**Multiple Forces**
More than one force can act on an object at the same time. The direction of a force is just as important as its strength. Sometimes multiple forces work together on something and their efforts are combined. When forces work in the same direction, then the force applied becomes greater. Consider a heavy wagon being pulled by one person and being pushed by another. Combining the force of both (applying a greater force) makes the wagon easier to move.

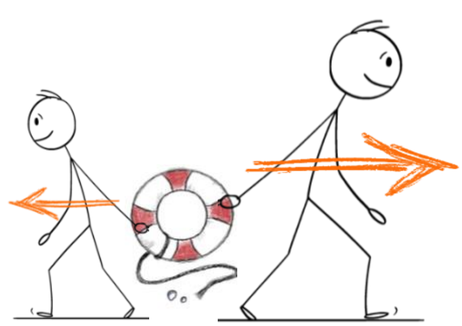


When forces work in opposite directions we first must determine if the forces are balanced or unbalanced. If the forces are balanced (of equal strength in opposite directions) the effect of one force will be cancelled out by its opposite force and there will be no change in movement.





However, if the forces are unbalanced (there is a greater force and a lesser force involved) the direction of movement will be determined by the greater force.



| | |
|---|---|
| | **Unseen Forces (Friction and Gravity)**<br>Friction is a force that makes it harder for things to move because it acts in the opposite direction; pushing against things and causing them to slow down or stop. There is friction between objects, air, and the surfaces they move across. Even if the surface seems smooth. A marble rolling across the floor, or a ball flying through the air, will eventually stop because the forces of friction and gravity will slow it down.<br><br>Gravity is an attractive force (pull) that acts on all objects. It's because of gravity that we fall down and not up; it is also the reason that when we toss a ball into the air the ball comes back down. Some students may use the term gravity when explaining why things fall "down" but may not yet realize that the direction of that pull is actually toward Earth's center.<br>**Keep in mind that occasionally it is necessary to sacrifice some of the details in favor of the big picture, especially when working with early learners. Big ideas in this unit focus on contact forces and do not include gravity. The term friction is not used but may be discussed in terms of something pushing the opposite direction.** |
| Materials | *For each student:*<br>• Science notebook<br>*For the teacher:*<br>• Book- *Equal Shmequal* by Virginia Kroll<br>• Chart paper and markers (or whiteboard)<br>• *Tug of War* animal strips<br>• Scenario cards<br>• *Video- Mini Golf Physics*<br>*For each pair/small group:*<br>• *Tug of War* animal strips |
| Prior Knowledge | When an object moves there is evidence that a force has acted on it.<br>The movement of an object is caused by a force that is either a push or a pull in a particular direction.<br>Students should be able to describe the relative strength and weight of things. (big/little, strong/weak, light/heavy) **See idea for practice at end of lesson** |
| Questions | **Driving Question**<br>• Why are some objects easier (or more difficult) to move than others?<br>**Probing Questions**<br>• What are some light objects that need a little bit of force to move them?<br>• What are some heavy objects that need a lot of force to move them?<br>• If we needed to move something heavy, what are some ways we could make that happen?<br>• How can you tell if teams are balanced (equal)?<br>• How can you tell if teams are not balanced (not equal)?<br>• When the teams are balanced, who wins? How do you know?<br>• How would the team(s) change if an elephant joined? A spider? |

## Launch (30 minutes)

**Engagement and Communication of Student Expectations**

During our last session, when you and your partner were choosing objects in the classroom to move using push or pull forces.

- Did anyone choose (*whatever the heaviest object in the room might be*)?
- Why not? If so, were you able to cause it to move?

*Students may say the object was too hard, too big, too heavy, had too much stuff on it, they may even tell you that it would take more than one student to move it.*

What I am hearing you say is that some objects are more difficult to move than others. If you agree, let me see a thumb up. If you disagree, let me see a thumb down. *(Take a moment to look at each student's response. Note those who disagree. It may be helpful to come back to them after partner discussions)*

Ok. In a minute, I'm going to ask a question. What I want you to do first is think quietly about your answer. Then I am going to ask you to turn to your shoulder partner and talk about your ideas. Then I'm going to ask a few students to share their explanation with the group. Ready?

- Why are some objects easier (or more difficult) to move than others?

  *Allow 3-5 seconds of <u>personal think time</u>.

  *Turn to shoulder partner.

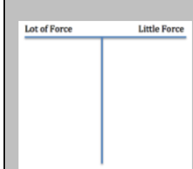
  *Set a timer for 1-2 minutes for partners to share/discuss ideas.

  *When time is up, ask three students to share out thoughts and ideas from their discussion.

*You may wish to ask for ideas from student's who earlier disagreed with the statement, *"…some objects are more difficult to move than others"* to see if they still feel the same way after discussing with a partner.

*Student responses may vary but should suggest the idea that heavier things are harder to move. Lighter things are easier to move. (To cause something to move/change position, sometimes you need a lot of force, sometimes just a little force.)*

**Note: It is possible that sophisticated thinkers may mention forces such as friction or gravity. While they may be able to discuss these concepts to some extent; beware of going too far off topic. Big ideas in this unit do not include gravity. The term friction is not used but may be discussed in terms of something pushing the opposite direction.**




In the science notebook, have students brainstorm objects that require lots of force to move, and objects that require little force to move.

Then, as a class, share ideas and create a 2-column chart.

- What are some light objects that need a little bit of force to move them? (*pencil, paper, a book, scissors, kitten, beach ball, etc*)

**Note: If you have students who suggest the need for an 'in-between' column… add to the chart to accommodate their thinking and encourage class discussion.**

Connect to lesson 1 moving a chair—What if we put a stack of big books on the chair? Would it move as easily? Why/why not? *(No. The books would make it heavier and it would require more force to cause it to move)*

- What if we had had to move a big box full of paper? *(The more paper, the heavier the box becomes. The more force is needed to move the box. Even if the individual pieces are light the combined weight adds up.)*

- What are some heavy objects that need a lot of force to move them? (*Filing cabinet, bookcase, teacher's desk, couch, elephant, car, etc)*

Let's look at the list of heavy objects.

- If we needed to move something heavy, what are some ways we could cause that happen? *(We could push or pull harder-we could get more than one person to help, we could try to make the object lighter- take files out of the cabinet or books off the shelves, we could use a tool- wheels, sliders, carts, etc)*

- What if we had another person (or more) working together to move something heavy?

  *Student responses may vary but should suggest the idea that together more people can move something heavy. People can combine their strength create a bigger push or pull. (To cause something to move/change position, sometimes you need a lot of force, sometimes just a little force.)*

- What if you all push against a dump truck, would you be able to move it?

  *(Probably not. The heavier an object, the greater the force needed to move it. Sometimes you can use a lot of force to try to move an object, but it does not move much or at all.)*

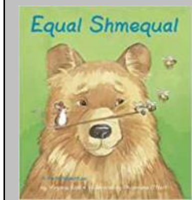
Complete these sentence frames in your science notebook- or as a class.

To move (heavy) objects, (lots) force is needed.

**OR** To move (light) objects, (little) force is needed.

***Students will explore concepts related to the following in part 2.**
**Listen to responses, but do not acknowledge ideas as right or wrong.**

- Suppose you and your friend want to use the same towel and are both equally strong. If each of you grabs an end and pulls at the same time using the same amount of force, what do you think will happen *(effect)*?
- What would happen (effect) if your older brother helps you?




**Part 2- Equal Shmequal** (20 minutes)
Read the book *Equal Shmequal*.

**Pause on page 5.** Ask students to think quietly to themselves about who they think will win the game. [Mouse] or [Bear]?

*Wait 3-5 seconds before asking for predictions.*
** Don't ask students why --not yet!*

**Pause on page 11.** Ask students to think quietly to themselves about who they think will win the game. [Bobcat and Wolf] or [Rabbit, Turtle, and Mouse]?

*Wait 3-5 seconds before asking for predictions.*
**Don't ask students why --not yet!*

**Pause on page 13.** Ask students to think quietly to themselves about who they think will win the game. [Deer, Wolf, and Bobcat] or [Turtle, Mouse, and Rabbit]?

*Wait 3-5 seconds before asking for predictions.*
** Don't ask students why --not yet!*

**Pause on page 19.** Ask students, with Wolf on one side, and Turtle on the other side is this equal? *(No. The seesaw is not balanced…straight across)*

**Page 20.** After reading about the first picture. Ask students, is this equal? *(No. The seesaw is still not balanced…straight across)*

After reading about the second picture. Ask students, is this equal? *(Not yet)*

**Pause on page 27.** Ask students, if both teams pull with equal effort (force), what happens? *(If both teams pull equally, no change. They are tied)*

- What is the goal of tug of war? *(The animals are playing a game where each team pulls on one end of a rope, trying to pull the other team over a line. The team that can pull with the greatest force (effort) wins.)*
- What do the animals do in the book to play a fair game of tug of war? *(The animals try to make balanced (equal) teams. The animals pulled with as much effort (force) as they could.)*

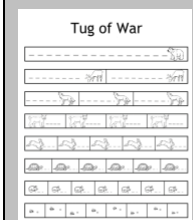
Explore (20 minutes)

Procedure

Tell students that their challenge is to find a variety of ways to model balanced forces between teams by using the *Tug of War* animal strips.

Share a few details about the strips:

- ✓ The length of the strip indicates the effort (force) the animal can pull with.
- ✓ Students may include multiples of the same animal on a team, if desired.
- ✓ Students will not use every card.




**Working with a Partner**

1. Review classroom norms for group work. *(Example below)*

    **G**et help when needed
    **R**espect each other
    **O**n task
    **U**se quiet voices
    **P**articipate actively

2. Pass out the *Tug of War* animal strips. One set per pair.
3. Student A will use the strips to create "Team A"
    Student B will use the strips to create a balanced (equal) "Team B"
4. Partners will check to see if Team A and Team B are balanced.

(when each team is lined up, the combined strips should be the same length overall)

**Math Connection (Comparing)**

If the effort/force of the teams created are not balanced (equal), students should be encouraged to discuss the teams' forces in terms of less than or greater than the other. Then predict which team would win AND explain why they think that team will win.

**Now that students understand what will happen, you will want to model what this looks like. In round 1, you may wish to limit Team A to 2 or 3 animals. As groups find success team size can increase.**

5. Allow students time to experiment with varying combinations. As they work, circulate first to address any procedural questions and then to observe and to listen to what students are talking about. Ask probing questions (see below) to further their thinking.
    - How can you tell if the teams are balanced (equal)?
    - How can you tell if the teams are not balanced (not equal)?
    - When the teams are balanced, who wins? How do you know?
    - How would the team(s) change if an elephant joined? A spider?

Summarize (10 minutes)

Communicate

**Group Discussion**

We've been doing a lot of thinking about forces. Think back to the mini golf video.

https://www.yout-ube.com/watch?v=GygGhvcAaPw It may be necessary to play the first few seconds for students.

- What caused the golf ball to start moving?

    *I want you to think silently to yourself about that for a minute.

    *Turn to a partner. Tell each other what caused the golf ball to start moving.

    *Ask a few students to share their responses. *(a force --a push--made the golf ball start moving)*

    - Which direction did the golf ball move *(effect)*? *(away)*
    - How many forces did we see in action? *(One. A Push from the putter.)*

We’ve also been thinking a lot about tug of war. Think quietly about how to play the game. Then I will ask a few students to help explain the game.

Ask for one idea, then ask another student what they can add. Continue until the class agrees they have all the details.

- What is the goal of tug of war?

  *(Each team pulls on one end of a rope, trying to pull the other team over a line. The team that can pull with the greatest force (effort) wins. A group pulling together can combine forces.)*

- What object are we watching the movement of? (*the rope*)
- What forces are necessary? (*pulls from each team member*)

**Project a picture of a game of tug of war.**


Ask students to look at Team A and think about the direction they are pulling. (Provide a few seconds for students to think)

- Tell students-Use your thumb to show me the direction of their force.

Then ask students to look at Team B and think about the direction they are pulling. (Provide a few seconds for students to think)

- Tell students-Use your thumb to show me the direction of their force.

In tug of war we need to think about each person and how they pull.

- Use your thumbs to show me the directions of both teams at once. (*Students should use both hands. Thumbs pointed opposite directions*)

What I am hearing you say is that more than one pull (force) can act on an object (the rope) at the same time AND they could be in opposite directions. If you agree, let me see a thumb up. If you disagree, let me see a thumb down. *(You may choose to ask a student or two for examples)*

- In tug of war, can we predict which side will win? (Yes. *The team pulling with the greatest force will win)*
- How do we know? (*Look at the direction and the strength of the forces. Find if the forces are balanced (equal) or not. The team pulling with the greatest force will win. The force of each person on the team is combined*)
- What if the teams are balanced (equal)? (*No change in motion. The game will be a tie*)
- What if the teams are balanced, but one person on a team stops pulling? (*The teams are no longer balanced (equal) and the other team wins)*

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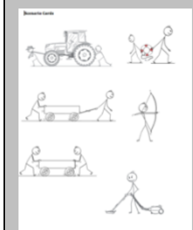
<td></td>
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**Scenario Cards**<br>
Show a card to the class.<br>
(Provide time for students to think about what they see)

Ask a few students to talk about what they see in the picture.

Tell students-Use your thumbs to show the direction of the forces.

(Do a quick scan to gauge student thinking)

Now ask students to think about which direction the **object** in the picture will move.

(Provide a few seconds for students to think)

Tell students-Use a thumb to show the direction of the movement.

If it will not move, cross your arms over your chest.

(Do a quick scan to gauge student predictions)

Ask several students to share their reasoning.

- What causes the _____ to move (or not move)?
- How do we know?

Discuss as many scenarios as reasonable to gauge student understanding. You may choose to return to the illustrations in *Equal Shmequal* or identify additional real-world scenarios for student discussion.<br>
You may choose to return to the scenarios posed earlier.

- Suppose you and your friend want to use the same towel and are both equally strong. If each of you grabs an end and pulls at the same time using the same amount of force, what do you think will happen? *(effect)*

*(Neither one of you will be able to pull the towel away from the other.)*

- What would happen (effect) if your older brother helps you?

*(His force, combined with yours, probably would be greater than your friend's force. Your friend would not end up with the towel because the towel would have moved toward the greater force of you and your brother.)*

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<td>Terminology and Concepts to Solidify</td>
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**Balanced-** of equal amounts

**Effort-** how much work is put into something

**Equal-** the same on both sides

*The meaning of "equal" is dependent on the context. Equal number is not always the same as equal size, strength, effort, or fairness.*

**Prediction-** what someone thinks will happen

**Strength-** The amount of force that is applied to an object

**Unbalanced-** not evenly distributed

**Weight-** the heaviness of an object

To move heavy objects, greater force is needed.

To move light objects, less force is needed.

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**Connection to Big Ideas (Phenomena)**

More than one force can act on an object at the same time.

How easily an object moves (or doesn't) depends on its weight and the strength of forces acting upon it.

**Follow Up/Practice**

**Container Question**
Find three identical containers-lids might be helpful. Fill one with rocks, one with dry beans or pasta, and one with cotton balls. Have children push them with one finger – which takes the most force to move? Least? Why?

**Push Pull Move (ppt on USB)**
As a class, use diagrams to discuss pairs of forces and results. (*unmoving/moving, which direction, is it a push or a pull?)* How do we know?

**Tug of War- What if……**
*This can be done by simply posing a scenario to students, or they can play the game in an open space. (There is a rope in the kit)

Predict who would win if:

| **Team A** | **Team B** |
|---|---|
| The teacher | One student |
| The teacher | Five students |
| Half the class | Half the class |
| Pulled the rope | Pushed the rope |
| ? | ? |

Explain why.
I think team _____ will win because_____.

**Literacy/ Cultural Connection**
*Rabbit Plays Tug of War* is known as a trickster tale, which are popular around the world. The leading character in these tales is often a mischievous animal.
As a class, name some tricksters from the stories you know. *(In addition to characters from children's books or movies- there may be students who have examples from oral tales- such as Iktomi, Coyote, Monkey, or Raven.)*
Read *Rabbit Plays Tug of War*- A Native American Legend. (Text at end of lesson)

- Who was the trickster in this story? (*Rabbit*)
- What made the snakes sure they could beat Rabbit in the game? *(Each snake thought they could pull harder- with more force- than Rabbit)*
- Why did Rabbit think the snakes would struggle in the tug of war? *(Rabbit thought the snakes were equal. If each pulled their hardest their forces would be equal/balanced and neither would win)*

Moral of the story: tricks have consequences. (*the result of an action*)

- What was the consequence of Rabbit's trick? (*Rabbit could no longer drink from his favorite place on the river bend)*

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**Tug of War Trivia**

Tug of war has been known by many cultures as: a game of fun, a game of skills and a contest of strength.

- An Egyptian wall engraving from around 2500 BC depicts the oldest known tug of war contest.
- Tug of war was often used to help warriors build their strength for battle.
- Tug of war was a summer Olympic event from 1900 to 1920.
- Canadian Inuits hold a version of tug of war called “aarsaraq” which is played sitting down.
- International *Tug of War Day* is celebrated on February 19 every year.

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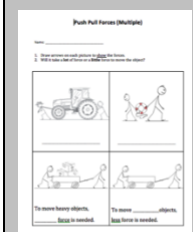
Assessment



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**The teacher will use student notebooks, discussions, and observations of students to assess progress and understanding of concepts.**

(Example) Scenario Cards

Use your thumbs to show the direction of the forces.

Use a thumb to show the direction of the movement.

If it will not move, cross your arms over your chest.

Will it take a lot of force or a little force to move the object?

How do we know?

**Push Pull Forces (Multiple)**

- Draw arrows on each picture to show the forces.
- Will it take a lot of force or a little force to move the object?
    - Form B allows students to circle choice.

**This or That? (ppt on USB)**

Explain why some objects are easy to move while other objects are difficult to move.

- Which is easier (or harder) to move?
- Why?
- Push or pull?

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## Prior knowledge (suggestions for practice)

Students should be able to describe the relative strength and weight of things. (big/little, strong/weak, light/heavy)

Help students consider a continuum of related words by order of degree.

1. Select a pair of opposite words. (big/little, strong/weak, light/heavy)
2. Brainstorm words that could be in the middle (in between the words on each end).
3. Generate two to three (or more) synonyms for each of the opposite words.
4. Arrange the words in a way that makes a bridge from one opposite word to the other. Continuums can be done horizontal or vertical.
5. Have students discuss their rationale for placing certain words in certain locations. Encourage a conversation about the subtle differences among the words.

**Example**

| **big** | | **little** |
|---|---|---|
| huge | medium | small |
| large | regular | tiny |
| massive | ordinary | microscopic |
| enormous | average | miniature |
| | | |

*In the next lesson- Students should be able to describe the relative strength, distance, and speed of things. (big/little, strong/weak, long/short, fast/slow)

# Rabbit Plays Tug of War

**A Native American Legend**
**(Creek/Muscogee Tribe)**

**retold by S. E. Schlosser**

Rabbit had a favorite place on the river where he always went to drink water. It was on a bend in the river, and two Snakes lived there, one on the upper side of the bend and one on the lower. Rabbit soon learned that neither of the Snakes knew that the other Snake lived there.

Ho, ho, ho, thought Rabbit. I am going to have a bit of fun!

Rabbit went to the Snake that lived on the upper bend of the river. "I am a very strong Rabbit," he told the Snake. "I bet I can pull you right out of the water."

"I bet you can't!" said the Snake, who was very strong indeed.

"I will go get a grape vine," said Rabbit. "You will pull one end and I will pull the other. "If I pull you out of the water, I win the contest. If you pull me into the water, then you win."

The Snake on the upper bend agreed. Then Rabbit went to the Snake on the lower bend and made the same deal. He told both Snakes that he would be standing out of sight on top of the riverbank and would give a whoop when he was in place and ready to start the contest. Both Snakes were pleased with the arrangement. They were sure they would win against such a feeble little Rabbit.

Rabbit took a long grape vine and strung it across the wide bend in the river. He handed one end to the first Snake and the other end to the second Snake. Then he gave a loud whoop from the middle of the riverbank and the two Snakes started tugging and pulling with all their might.

"That Rabbit is really strong," thought the Snake on the upper bank. He would tug and tug and the vine would come a little closer to him and then he would nearly be pulled out of the water.

"Rabbit is much stronger than he appears," thought the Snake on the lower bank after he was almost hurled out of the water by an extra strong pull from up the river.

Rabbit sat on the bank above both Snakes and laughed and laughed. The Snakes heard him laughing and realized that they had been fooled. Letting go of the rope, they swam to the middle of the bend and met each other for the first time.

Both Snakes were angry with Rabbit for making them look foolish. They agreed that Rabbit could no longer drink from his favorite place on the river bend where they lived. Despite his protests, they sent Rabbit away and would not let him come down to the riverbank anymore. So, whenever Rabbit grew thirsty, he had to turn himself into a fawn in order to get a drink from the river.

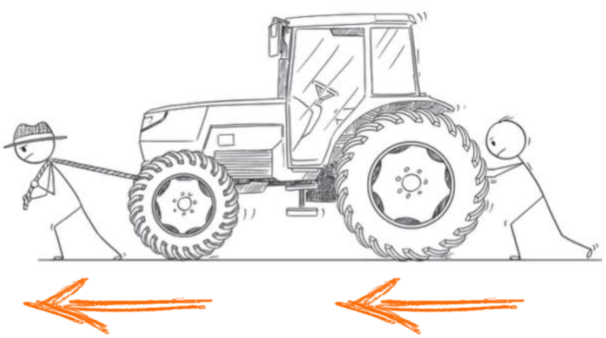
After that, Rabbit decided not to play any more jokes on Snakes.

https://americanfolklore.net/folklore/2010/07/rabbit_plays_tugofwar.html

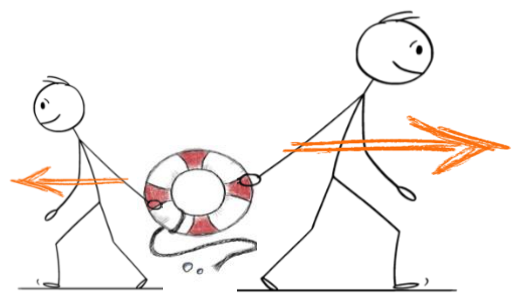
# Push Pull Forces (Multiple)

Name ___Your Student___

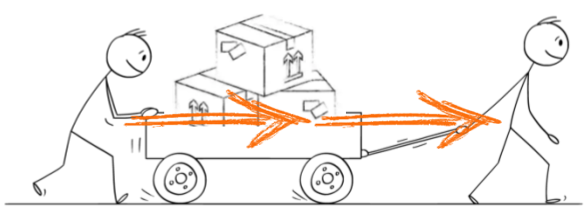
1. Draw arrows on each picture to show the forces.
2. Will it take a **lot** of force or a **little** force to move the object?



___Lot___

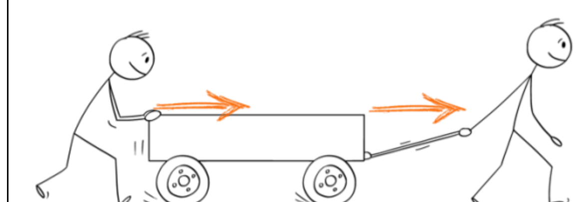


___Little___



To move heavy objects,

___more___ force is needed.



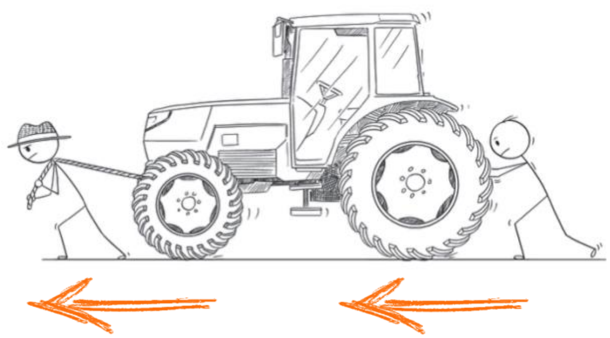
To move ___light___ objects,

less force is needed.

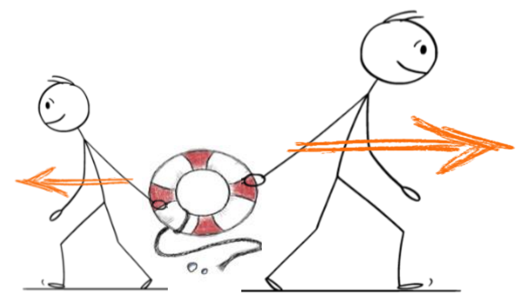
# Push Pull Forces (Multiple)

Name Your Student

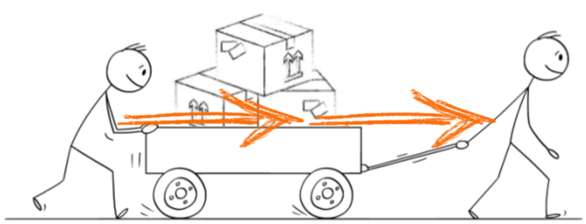
1. Draw arrows on each picture to show the forces.
2. Will it take a **lot** of force or a **little** force to move the object?



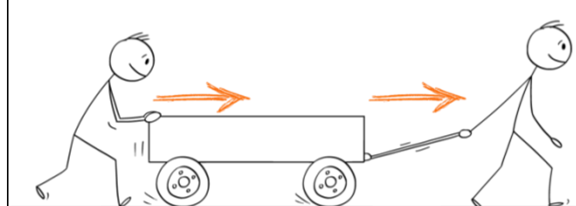
**Lot** **Little**



**Lot** **Little**



To move heavy objects, less / more force is needed.



To move light / heavy objects, less force is needed.

<table>
<tr><th>Lesson 3</th><th>Going the Distance</th></tr>
<tr><td>Overview<br>Standard(s) &<br>Objectives</td><td>Overview<br>In this lesson, students will explore varying strengths of forces in order to manipulate object speed (fast/slow) and distance traveled. This will help them understand that the motion (change in position) of an object is related to the strength of the push or pull applied.<br><br>Building Toward<br>K-PS2-1 Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.<br><br>Crosscutting Concept<ul><li>Scale, Proportion, and Quantity- Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower)</li><li>Stability and Change- Some things stay the same while other things change. Things may change slowly or rapidly.</li></ul>Science and Engineering Practice<ul><li>Planning and Carrying Out investigations- with guidance, plan and conduct an investigation in collaboration with peers.</li></ul>Objectives<br>Students<ul><li>Recognize that motion can be observed, described, and measured.</li><li>Demonstrate that varying the amount of force applied will affect the motion (speed/distance) of an object.</li><li>Explain that an object’s movement is related to the strength of the push or pull applied.</li></ul></td></tr>
<tr><td>Background<br>Information</td><td>More About Motion<br>Motion is a key characteristic of all matter. It can be observed, described, and measured. When riding a bicycle, you pass by houses and trees; you can see (observe) that you are moving. The direction of motion can be described. You might say that you rode away from your house, or that you pedaled north up the hill.<br><br>To further describe the motion of the bicycle it is necessary to talk about things that can be measured, for example how far did it move? Feet, blocks, miles? How long did it take? Minutes, hours, days? Each describes a very different journey.<br><br>Moving objects have speed. Speed describes how long an object takes to move a certain distance. Speed may be described as fast or slow. Speed may also tell the distance and time elapsed; for example, 25 miles per hour.</td></tr>
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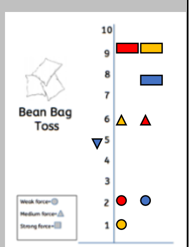
| | |
|---|---|
| | **A Lot or a Little**<br>Have you ever raced on a bicycle? To cause a bicycle to move, you push on the pedals. To go faster, you push harder. The greater the force you apply, the faster the bicycle moves. The greater the force you apply to the brakes, the faster it stops! Changing the amount of force applied to an object has measurable effects on the movement of the object. Students are aware that a door can be closed gently, or it can be slammed shut by varying the amount of force applied. This concept transfers to many situations, but learners may not always stop to consider these cause and effect relationships.<br><br>**Fast and Far**<br>In general, the greater the force, the greater the change in motion. If an object is pushed or pulled with great force it will move faster and farther than if a lesser force was applied. If a ball is kicked with lots of force, it will move quickly away from the kicker. It will also move farther away than a ball that was gently kicked. |
| Materials | *For each student:*<br>• Science notebook<br>*For the teacher:*<br>• Chart paper and markers (or whiteboard)<br>• Wooden car (part 1)<br>• *Video- Mini Golf Physics*<br>*Part 1 (distance)--For each pair/small group:*<br>• Bean bags- number line- tape- marking shapes<br>*Part 2 (speed)--For each pair/small group:*<br>• Toy cars- tracks- tape<br>• Books or blocks |
| Prior Knowledge | A force has both strength and direction.<br>Students should be able to describe the relative strength, distance, and speed of things. (big/little, strong/weak, long/short, fast/slow)<br>**See idea for practice at end of lesson 2** |
| Questions | **Driving Question**<br>• What causes an object to move fast or slow?<br><br>**Probing Questions**<br>• What happens to an object (effect) when you push or pull with great effort compared to when you push or pull with little effort?<br>• If you move fast/slow does it take a long time to get somewhere?<br>• What caused the car to move faster/slower down the ramp? |

| Launch (10 minutes) | |
|---|---|
| Engagement and Communication of Student Expectations | (Prepare) Place a wooden car on an open space on the floor, where all students will be able to see it AND the teacher can reach it.<br><br>Gather students for a large group discussion.<br><br>Remind the class that they have been studying what causes objects to move and practicing how to describe the movement of objects.<br><br>Facilitate a quick popcorn review…. Randomly "pop" around the room to call on students and hear what they have to say in response, then randomly call on a few more to find out if they agree, disagree, or have something to add.<br>• Is this car moving? (*No*)<br>• Why isn't it moving? (*It needs a force- a push or a pull in order to move*)<br><br>Encourage students to tell you how to cause the car to move.<br>(A student could take your place as the pusher/puller)<br>• Should I use a push or a pull?<br>• Show me with your thumb which direction that will cause it to move.<br>• Like this? Give the car a tiny push or pull (*it should barely move*).<br>• Like this? Use a significant amount of force on the car (*far and 'fast'*).<br>• What was different each time the car was pushed or pulled?<br><br>Call on a few students to share what they noticed. (*Responses may vary but may include a difference in how soft or hard the car was pushed/pulled, that one used a stronger/weaker force than the other, that one distance traveled was shorter/longer than the other, that one push or pull moved the car faster/slower than the other*)<br><br>**Note:** Allow students to have their own opinion about fast and slow since the terms are relative at this level.<br>Ask the students the following questions. Accept all ideas without correction- they will have a chance to explore next. You may wish to capture student responses to discuss to during the lesson summary.<br>• What caused the car to move fast/far?<br>• What situations can you think of where it is important to be able to control the forces applied to objects? |
| **Explore (20 minutes)** | |
| Procedure | Today we are going to explore how objects respond when we vary (change) the strength of the force used to cause them to move.<br>✓ Divide students into small groups- no larger than 4.<br>✓ Each student will take turns in his or her team.<br>✓ Every student will record data in science notebooks.<br>✓ Remind students that they are scientists, and the materials are science tools and not toys. |

**Advanced preparation**
For each small group (maximum 6 groups) create a working space for bean bag toss. Layout a number line with the number 1 at your feet and the number 10 away from you. **See diagram in the side bar below** Place a strip of tape across the leading edge of the number line to hold it in place. It is a good idea to extend the tape so that students have a visual indicator of where to stand during each toss.

**Exploring Distance Materials**
- Bean bags (Different color for each person)
- Number line
- Tape
- Marking shapes




**Part 1- Exploring Distance**
**<u>Bean Bag Toss</u>**

1. Each student should select <u>one</u> bean bag to use.
2. One student should stand with toes behind the tape line.
3. Use an underhand toss to cause bean bag to move away.
   - First use a weak force.
4. Place marker (circle) where the bean bag landed.
5. Record in science notebook
6. Rotate until each team member has a turn.
   - Repeat using a medium force. (triangle)
   - Then using a strong force. (square)

- *Teams should attempt to control force used so that the bags do not land beyond the #10*

7. If there is time remaining….try for bean bag to land on the "7"
   - Record where it landed, and amount of force used.

(weak/medium/strong)

**Extension.** Choose a distance the object must travel. Have students vary the force required to cause it to move that distance.

**Sharing Results (10 minutes)**
- What kind of force is used in a bean bag toss? (*a push*)
- How do you know? (*the bean bag moves away*)

Look at your data- groups can walk around room to look at markers on ground at each station, or project several science notebook pages.

- What does the data tell you about (effect of) using a weak force? (*the bean bags did not go very far, the numbers for the weak force are smallest*)
- Find the data for those that traveled farthest-what kind of force was used? (*strong force*)
- What patterns did you see in your data?
  - Weak force= bean bag traveled shorter distance
  - Medium force= bean bag traveled medium distance
  - Strong force= bean bag traveled longer distance

*For each marker (cluster) the weak force (circles) should be the smallest numbers, the strong force (squares) the largest numbers.*

**Note:** There is no expectation that data be recorded using standard measurements. Students can compare results using greater than/less than terminology, such as, "The bean bag went farther when..."

**Exploring Speed Materials**

- Toy cars
- Tracks
- Tape
- Books or blocks

**Advanced preparation**

Gather six like items (books, blocks, cups etc) for each group of three students. These will be used to raise ramps during the exploration.

**Part 2- Exploring Speed (20 minutes)**

We have been talking a lot about distance (how far) objects travel. I've been wondering…

- What are some ways we could find out how fast something is moving? (*Students may talk about watching or tools-stopwatches, timers, radar, etc.*)

  **Optional video on USB*

- If we had two objects, how could we find out which was the fastest, without using fancy equipment? (*Hopefully, the students come up with the idea of some type of comparison- or race. If each object starts at the same time, and travels the same distance, the first object across the finish line traveled fastest.)*

**Show students one of the blue plastic tracks and a car.**

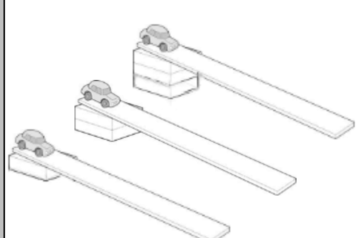
Let them know that they will be working in groups of three. Each student will receive one track and one car, as well as tape and books/blocks.

Ask for ideas about how they could design an investigation, using these items, to change the speed of their car without pushing it with their hand.
(*Students should be able to explain that the car will need some sort of force to move. With some luck, at least one student may say that one end of the track could be raised so that the cars will move.)*

If necessary, this is the place to introduce the term ramp. (*a flat surface with one end higher than the other*)

- When we compare, how do we know which was the fastest? Slowest? (*the fastest will cross the finish line first. The slowest will cross the finish line last*)
- For a comparison to be fair, what do we need to do the same? (*objects should be similar, start at the same time, have the same finish line, and no one should push*)
- What should be different? (*height of the ramp*)

Ask students to think about how they can make sure that they have set up a fair comparison and that the cars start at the same time, travel the same distance, and have the same finish line. *(no one should push.)*



**Build**

Students will work in groups of three.

- Person 1 will create a low ramp.
- Person 2 will create a medium ramp.
- Person 3 will set up a high ramp.

**Once ramps are created**

1. Decide how far (distance) the cars will race, then use a piece of tape to mark the finish line.
2. Make a prediction about which ramp will cause the car to move fastest and record it in your science notebook.
3. After you have made your predictions, each team member should hold a toy car at the top of the ramp (starting line).
4. On the count of three, all group members will release their car- taking care not to push.
5. Watch the finish line carefully.
6. Record your observations in your science notebook.
7. Repeat two more times.

(Optional) Measure the distance from the starting line to the finish line.
Time how long it takes a car to travel from the starting line to the finish line.
For example.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \qquad \text{Speed} = \frac{30\ \text{cm}}{3\ \text{seconds}} \qquad \text{Speed} = 10\ \text{cm/s}$$

**Sharing Results (10 minutes)**

- Did your prediction match what you observed? (*ask several students*)
  - If yes, what made you think that ramp would cause the car to go the fastest?
  - If no, what did you discover instead?
- Which ramps caused the car to move fastest? Why? (*answers will vary*)
- What did it help you see? (*the higher the ramp, the faster the car traveled*)

**Note:** Students are often surprised to discover that sometimes cars will curve or change directions at the end of the ramp. This would be a great time to think about why this might happen (hypothesize). (*The slower cars were more stable on the testing surface/ or the faster cars were less stable on the testing surface—speed can affect control*)

Summarize (10 minutes)

Communicate

**Group Discussion**
At the beginning of the lesson we discussed forces.

- What caused the car to move fast/far? (the strength of the force)
- What situations can you think of where it is important to be able to control the forces applied to objects? (sports or games: like golf or bowling; may be popular responses. Students may even mention that everyday actions like hugging a friend, opening/closing doors, petting an animal or even patting a friend on the back are important to control)
- Which ideas on our original list do we need to fix?
- What new ideas can we add?

We are going to look back at the mini golf video (first 30 seconds only).
https://www.yout-ube.com/watch?v=GygGhvcAaPw

| | |
|---|---|
| | • How can we describe the forces used to make the golf ball move? (*A push made it start moving. A great force must have been used- the ball was hit hard to make it go a long distance. It is also possible that students will mention that hitting the ball with more force will make it move quickly.)*<br>• When making any object move, does it matter how hard the object is pushed (or pulled)? Why or why not?<br>(*Yes. The change in an object's motion is related to the strength of the push or pull. A stronger force moves an object a larger distance than a weaker force. A weaker force does not move an object very far or very fast*.)<br>(*It's important to get the force just right….too soft- not far or fast enough, but if too hard the object may go too far or too fast*.)<br>• How can you cause an object to go farther? Not as far?<br>• How can you cause an object to go faster? Not as fast?<br>*(We can vary our push or pull on an object. Hard pushes/pulls can cause an object go farther/faster than soft pushes/pulls. We can use a <u>ramp</u> like we did in part 2. The higher the ramp the farther/faster it will cause the object to move.)*<br>• What are places we find 'ramps' in our world? Make a class list. (*loading ramps, wheelchair ramp, slides, skateboard park, skiing/snowboarding, roofs - and many more*) **Sample photos can be found on unit USB**<br>• For each type of ramp, decide if they are used to cause things move fast or slow. (What would happen if a friend in a wheelchair had to go up or down a tall ramp?)<br>Complete these sentence frames in your science notebook- or as a class.<br>The (*<u>more</u>*) force I use, the (<u>farther/faster</u>) an object moves.<br>**Or** The (*<u>less</u>*) force I use, the (<u>less distance/slower)</u> an object moves.<br>The (higher/lower) the ramp, the (faster/slower) it causes an object to move. |
| Terminology and Concepts to Solidify | **Data-** information collected for analysis<br>**Distance-** the amount of space between two points- how far<br>**Fast-** moving quickly<br>**Ramp**- a flat surface with one end higher than the other<br>**Slow-** not quick<br>**Speed-** how long it takes an object to move a certain distance<br>**Strong**- a great force (powerful)<br>**Weak**- only a small force<br>An object's motion is related to the strength of the push or pull. |
| Connection to Big Ideas (Phenomena) | To cause something to move, sometimes you need a lot of force, sometimes just a little force.<br>Forces can be applied in different amounts. When more force is applied to an object, more movement will be observed. When less force is applied to the same object, less movement will be observed. |

| | |
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| Follow Up/Practice | **Play a game that is all about forces and how hard you hit the object!**<br>Paddle Relay<br>Have students write their name on a small paper plate, then use masking tape to tape a ruler to the back of the plate. (If your school has ping pong paddles you could use these instead) Blow up several balloons to use as the "ball" in case one pops.<br>During the game, only the teacher can touch the "ball" with their hands. Everyone else must use their paddle.<br>Give the players a challenge that's appropriate to their skill level and your available space. For example, team relay. Get ball from point A to point B. Every person on the team must hit the ball at least one time (or each person can only hit the ball once)<br>Tee'd off --Outdoor or PE extension<br>Set up a t-ball post. Form two groups. One will be hitters, the other will measure and record results/data (adults provide assistance as necessary). Groups will switch so that each student has an opportunity to hit/measure/record.<br>Encourage students to lightly hit the ball and then hit it with more force. Measure how far the ball travels in each instance, then compare the distances to help students see that the harder hits pushed the ball much farther than the lighter ones.<br>**Direction, Strength, Distance, Speed**<br>Brainstorm words and practice describing movement.<br>Have students help you brainstorm words for each category that can be used to describe movement. Below are some examples students may come up with: |

| Position | Direction | Strength | Distance | Speed |
|---|---|---|---|---|
| in front/behind | left/right | strong | near | fast |
| above/below | up/down | weak | far | slow |
| on/off | away/toward | powerful | long | quick |
| between | north/south<br>east/west | average | short | medium |
| over/under | | faint | part way | moderate |

| | |
|---|---|
| Assessment | **Going the Distance**<br>1- You've been asked to design new slides for the playground!<br>Your manager wants two kinds of slides because not everybody wants to go fast.<br>• *Students should be able to show by drawing/writing- A high/tall slide will cause a person to move fast. A low/short slide will produce little speed.* |

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2- Bean Bag toss
What advice would you give Taylor if the goal of the game was to get the bean bag in bucket #5? What about bucket #3?
<ul><li>Students should explain that varying the amount of force applied will affect the distance. A strong force is needed to move to bucket #5. Less force is needed to reach bucket #3.</li></ul>


</td>
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</table>

# Going the Distance

Name Your Student

You've been asked to design new slides for the playground!

Your manager wants two kinds of slides. Draw your designs below.

| For people who want to go **fast**.<br><br>A high/tall slide will cause a person to move fast. |
|---|
| For people who want to go **slow**.<br><br>A low/short slide will produce little speed. |

**What is different?**

The height of the slide.

# Going the Distance

Name Your Student

- What advice would you give Taylor if the goal of the game was to get the bean bag in bucket #5?
- What about bucket #3?


Students should explain that varying the amount of force applied will affect the distance. A strong force is needed to move to bucket #5 farther away. Less force is needed to reach bucket #3 since it isn't as far away.

| Lesson 4 | A Change of Plans |
|---|---|
| Overview Standard(s) & Objectives | **Overview**<br>During this lesson, students will learn that once an object is moving, it requires another force to change speed or change direction. Students will make many discoveries about what happens when objects collide and how pushes can cause an object to change speed or direction.<br>**Building Toward**<br>**K-PS2-1** Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.<br>Crosscutting Concept<br>• Cause and Effect- simple tests can be designed to gather evidence to support or refute student ideas about causes.<br>Science and Engineering Practice<br>• Planning and Carrying Out investigations- with guidance, plan and conduct an investigation in collaboration with peers.<br>**Objectives**<br>Students<br>• Recognize that once an object is moving, it requires another force to speed up, slow down, stop or change direction.<br>• Identify changes in motion (speed and direction).<br>• Explain that when objects collide, an object's speed or direction can be changed.<br>• Demonstrate and explain that heavier objects are harder to start/stop/re-direct than lighter objects. |
| Background Information | **Changing Speed or Direction**<br>In previous lessons, it was determined that push and pull forces can cause objects to begin moving. Interestingly, once an object is moving, it requires another force to speed up, slow down, stop or change direction. Some examples are pedaling a bicycle, catching a ball, or hitting a ball with a bat.<br>Varying the amount of force applied to moving objects will determine whether the object will change speed (or direction) slowly or quickly. Keep in mind that a bigger force will cause an object’s movement to change more quickly than a smaller force.<br>Students may not fully understand what causes a moving object to stop. They may say something like, “the push wore off.” They know the object has stopped but cannot yet attribute the stopping action to a force. They will need experience and assistance to understand that when catching a ball, it’s the force of their hands that stops the ball from moving farther.<br>**It is possible that sophisticated thinkers may mention friction or air resistance. These concepts should be discussed in terms of something pushing the opposite direction of the moving object.** |

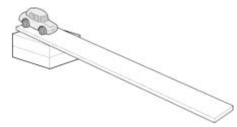
| | |
|---|---|
| | **Taking Control**<br>Knowing how and why things move is important because so much of everyday life depends on predicting and controlling motion. We are able to make those decisions because we understand how things move when certain forces act upon them.<br>If we push something, it moves away from us. If we pull it, it moves toward us. If we apply a force to a moving object, it will change speed or direction. We can regulate the amount of force used when causing things to move, changing speed, or direction. Knowing how things move allows us to work, play, travel, and complete everyday tasks with confidence. |
| Materials | *For each student:*<br>• Science notebook<br>*For the teacher:*<br>• Chart paper and markers (or whiteboard)<br>• Toy car- track- books or blocks (part 1)<br>• Tennis ball (part 2)<br>• *Video- Mini Golf Physics*<br>• (More Practice) Book- *Sheep in a Jeep* by Nancy Shaw<br>*Part 1 (changing speed)--For each pair/small group:*<br>• Toy cars- tracks- books or blocks- tape- various test objects<br>*Part 2 (changing direction)--For each pair/small group:*<br>• Tennis balls- wiffle balls- ping pong balls -racquet balls |
| Prior Knowledge | When an object moves there is evidence that a force has acted on it.<br>How easily an object moves (or doesn't) depends on its weight and the strength of forces acting upon it.<br>To cause something to move, sometimes you need a lot of force, sometimes just a little force. |
| Questions | **Driving Question**<br>• How can you change the motion of a moving object? (Speed or direction)<br>**Probing Questions**<br>• Tell me about the type of object that was needed to stop the car. What made it effective?<br>• What other things could we put at the end of the ramp that might stop the cars? Why do you think they would work?<br>• Even if the object did not stop the car, do you think it changed its speed in another way?<br>• When the car pushed on your hand, what did your hand do? How do you know?<br>• What happened when another ball collided with the racquet ball?<br>• Do you think that anything we rolled the racquet ball into would cause it to change direction?<br>• What would an object need to be like to cause the racquet ball to change the direction? |

Launch (10 minutes)

Engagement and Communication of Student Expectations

**Advanced preparation**

Place a toy car and ramp set-up in an open space on the floor, where all students will be able to see it AND the teacher can reach it.



During one of our last sessions we experimented with ramps.

- What did the ramps help us learn about the <u>speed</u> of the cars? (*The high/tall ramp caused the cars to go the fastest. Cars on the low ramp did not go as fast.*)

We observed as cars traveled down ramps- just like this (let go of the car and allow it to roll down the ramp). Since then I've been wondering...what if I wanted the car to stop near the bottom of the ramp? What would I need to do?

*Think (silently) about that for a minute.

*Turn to a partner. Tell each other what you might try to stop the moving car.

*Ask a few students to share their ideas. (*Responses will vary but should include the idea of placing something at the bottom of the track.*)

*The facilitator should act as recorder. Keep a record of student ideas on chart paper or the whiteboard.*

- What other things could we try? (*add additional responses to list*)
- If we put something at the bottom of the track to stop the car…I wonder if it would matter what the thing is?

Let's find out!

Explore (20 minutes)

Procedure

**Changing Speed Materials**

- Toy cars
- Tracks
- Books or blocks
- Tape
- Test objects: index card, chapter book, sponge, eraser, plastic cup, rice

**Part 1- Changing Speed-Stopping**

Tell students they will work with a partner to set up a ramp to find out which items will cause the car to stop.

1. Before you test these items, you are going to make a prediction in your science notebook. You may lift and touch each item. Do you think the item will stop the car? If you think it will, circle yes. If you do not think it will, circle no.
2. Once you have made a prediction for each item, set up your ramp.
3. Decide how far away from the end of the ramp the test items will be placed, then use a piece of tape to mark where to set the objects.
4. Take turns. Test each item one at a time (do not make any changes to your ramp).
5. Record your observations in your science notebook.

**Extensions:** If you have space in your classroom, you may wish to set up a station where students can experiment with additional items.

**Sharing Results (10 minutes)**

- Which objects were able to stop your car? (*book, eraser, weighted cup, hand, maybe sponge- answers may vary- in some instances the sponge will move a fair distance before stopping the car. The sponge is a special case- the material allows it to stay in contact with the car for a longer time and can stop it even though it is not as massive as the car. Testing surface also plays a role.)*
- Why do you think they were able to stop the car? (*they were able to apply enough force to change the speed of the car)*
- Tell me about the type of object that was needed to stop the car? What made it effective? (*the more massive object was able to stop the car*)
- What other things could we put at the end of the ramp that might stop the cars? Why do you think they would work? (*answers will vary*)
- Even if the object did not stop the car, do you think it changed its <u>speed</u> in another way? (*slowed it down*)(*students may note change in direction as well)*
- What are some other words we can use to describe an object that is changing speed? (*speeding up, slowing down, stopping, starting*)

As you tested each item, the car and the item had to come in contact with each other to see if the car would stop. In science, there is a term used to describe when two (or more) objects crash into each other. Introduce- *collide*.

Ask one or two students to use the word collide in a sentence.

- What did you feel when the car collided with your hand? (*When the car collided with my hand I felt a push. The car tried to move my hand away.*)
- When the car pushed on your hand, what did your hand do? (*My hand pushed back on the car*)
- How many forces were there? (*two- one from hand, one from car*)
- What forces were they? (*both pushes*)
- How do you know? (*the car moved away from my hand a little bit when it stopped*)

**Note:** if students did not notice this, you may need to allow students some time to try this so they can see/feel it for themselves.

What I am hearing you say is that it was the force of your hand that stopped the car from moving farther. If you agree, let me see a thumb up. If you disagree, let me see a thumb down.

Okay, help me complete this sentence about our learning today. When objects collide they can change (<u>*speed*</u>).

**Note:** If students generalize and say motion or stop or slow down, work with them to identify how the motion changes—slows down or stops= change in speed.

**Part 2- Changing Direction**

(Prepare) The teacher will need a tennis ball and a larger fixed object for the ball to roll into. A wall or door is most likely available, but you could also choose the side of a filing cabinet, etc. Just make sure that to choose a relatively large target. Select a space where all students will be able to see the demonstration AND there is enough space to accommodate the rebound. You may wish to practice to get the force just right; the demonstration should be exciting, but not dangerous :0)

Show students the tennis ball. Tell them that you plan to forcefully roll the ball into the object.

- Imagine what will happen.
  *Allow 3-5 seconds of personal think time.
- Describe the motion of the ball to a partner.
  *When time is up, ask several students to share their predictions.

Roll the ball with enough force that it hits the object AND changes direction.

Discuss with the students what they observed. Encourage several students to respond to each question and share thinking.

- When the ball first started rolling, which direction was it going? (*students may point or say toward the object or away from your hand*)
- What caused the ball to start moving? (*a force from your hand*)
- What force was applied to the ball? (*a push*)
- After it hit the object, which direction was the ball going? (*students may point or say away from the object)*
- What caused the tennis ball change directions? *(a force from the object- a push)*
- How do you know? (*the direction of the ball changed*)
- How many forces were in the collision? (Two. One from the ball and one from the object)
- Why didn't the object move? (*It's made of a solid material, its attached to the floor, its more massive, etc*)

Today we rolled a tennis ball into an object that was not moving, and last time our experiment was designed so that the cars would collide with an object at the bottom of the ramp that was not moving.

Sometimes objects collide when both objects are moving.

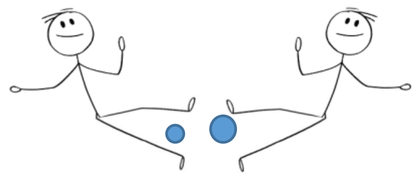
- What examples can you think of?
  *Think (silently) about that while I count to ten.
  *Turn to a partner. Share one example with each other.
  *Ask a few students to share their ideas. (*Responses will vary but might include two moving cars, two moving balls, two children playing a game, a bat hitting a ball, etc.*)

**Changing Direction Materials**

- Tennis Balls
- Wiffle Balls
- Ping pong balls
- Racquet balls

Next you will work in small groups to see what happens when moving objects collide with other moving objects!

- ✓ Remind students that they are scientists, and the materials are science tools- not toys.
- ✓ Divide the class into groups of 4 students. Have them sit across from each other (in pairs) with legs outstretched, their feet need not touch.
- ✓ Explain the ground rules. During the experiment, students will take turns rolling balls at other balls. The balls must stay on the ground (no throwing).
- ✓ They want balls to collide during the experiment so they can observe what happens. They should use their outstretched legs to keep the balls from escaping their investigation.



Before testing these items, you are going to make a prediction in your science notebook. You may lift and touch each item. Do you think the ball will change direction if it collides with the racquet ball? If you think it will, circle yes. If you do not think it will, circle no.

- ✓ Let the students practice collisions for a few minutes before starting their investigation. Depending on the dexterity of the students, it may take some practice and patience.

- Each pair of students will have two balls at a time. They should watch each collision carefully to see what they notice. The only observations that will be tracked in their science notebooks occur when one of the balls is a racquet ball.

The facilitator may wish to name ball pairings to ensure efficiency.
*(Parings in gray should be entered in science notebook)*

| **Pair A** | **Pair B** |
|---|---|
| Racquet Ball—Ping Pong Ball | Wiffle Ball—Tennis Ball |
| Wiffle Ball—Tennis Ball | Racquet Ball—Ping Pong Ball |
| Racquet Ball—Wiffle Ball | Ping Pong Ball—Tennis Ball |
| Ping Pong Ball—Tennis Ball | Racquet Ball—Wiffle Ball |
| Racquet Ball—Tennis Ball | Ping Pong Ball—Wiffle Ball |
| Ping Pong Ball—Wiffle Ball | Racquet Ball—Tennis Ball |

Discuss with your partner.

- What happened when the balls collided?
- What patterns did you notice?
- What would be different is we added a basketball?

<table>
<tr><td></td><td>Sharing Results (10 minutes)<br>Facilitate a class discussion. Remember to allow a few moments of personal think time before asking students to share their thinking aloud. Pose <u>only one</u> question at a time. Make sure to take the time to hear from many students (agree/disagree)
<ul>
<li>What happened when the balls collided? (they changed direction)</li>
<li>What patterns did you notice? (the light balls changed direction more easily/faster than the bigger ones)</li>
<li>What would be different is we added a basketball? (a basketball is much more massive; the other balls might not have an effect on its path/direction/speed)</li>
<li>What happened when another ball collided with the racquet ball? (The lighter (less massive) balls had little effect on the racquetballs motion- the light balls changed direction/speed. The heavier (more massive) tennis ball caused the racquet ball to change direction)</li>
<li>Do you think that anything we rolled into the tennis ball would cause it to change direction? (no)</li>
<li>What does an object need to be like to cause a change the direction of another object? (it needs to be more massive - or moving with a lot more energy-faster)</li>
</ul>
Help me complete this sentence about our exploration today. When moving objects collide, they can change (<u>direction</u>).<br><br>Note: Students may also say speed, after exploring they should be able to identify both speed and direction as changes- this lesson focuses on one at a time.</td></tr>
<tr><td colspan="2">Summarize (10 minutes)</td></tr>
<tr><td>Communicate</td><td>Group Discussion<br>We have been learning about how a collision can change the speed or direction of objects. Let’s take a closer loose at the mini golf video and look for collisions. Call out “Boom” each time your see a collision!<br>https://www.yout-ube.com/watch?v=GygGhvcAaPw
<ul>
<li>What do you predict would happen if someone else’s golf ball hit the ball in the video? (if the other persons ball hit it very hard or very fast it could make it change direction or speed—faster, slower, stop)</li>
<li>What do you think might happen if instead you hit the ball in the video (while it was moving) a second time with the putter? (if I hit it in the same direction, it could go faster, it could change direction or speed)</li>
</ul>
I’d like to take what we are learning and apply the science to a different object…a bicycle! (Depending on student experience your example may become a tricycle or scooter)
<ul>
<li>What force causes the bicycle to start moving? (feet push on pedals)</li>
<li>How do you slow down or stop a bicycle? (Pull on the hand brakes or push backward on pedal brakes) (some may even say put down bottoms of feet- this force is a push)</li>
<li>If you slow down or stop the bicycle what are you changing? (its speed)</li>
<li>What will happen if a bicycle collides with a tree? (because the tree is more massive it will stop the bicycle) (change its direction)</li>
</ul></td></tr>
</table>

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<tr><td></td><td>

- How do you know? (*when the toy car collided with a more massive item at the bottom of the ramp the car stopped moving*) (changed direction)

**Note:** In each instance the force applied to stop or slow the object is in the opposite direction of its movement.

- What can we do to cause the bicycle to speed up? (*pedal with more force*)
- Do you just pedal one time really hard? (*No, you need to keep pedaling. Each pedal is another push. Lots of pushes added together will cause the bicycle to speed up*)  Another example might be pushing someone on a swing.

**Note:** In each instance the force applied to speed up the object is in the same direction as its movement. Students may also mention ramps or going down a hill. The longer the bicycle is on the downhill, the more speed it gains.

- How do you change the direction of the bicycle? (Apply a *push or pull force on the handlebars) (lean to the left or right)*
- What is something else that could change the direction of a moving bicycle? (*a collision- something could crash into the bicycle was moving.*)

Complete these sentence frames in your science notebook- or as a class.

When objects (*collide*), an object's (*speed*) or (*direction*) can be changed.

The more (*massive*) an object is, the less effect a given force will have on its motion.

</td></tr>
<tr><td>Terminology and Concepts to Solidify</td><td>

**Collide**- when two (or more) objects crash into each other

**Massive-** a large amount (scale or degree)

When objects collide, an object's speed or direction can be changed.

The more massive an object is, the less effect a given force will have on its motion.

</td></tr>
<tr><td>Connection to Big Ideas (Phenomena)</td><td>

Once an object is moving, it requires a force to speed up, slow down, stop or change direction.

A force has both strength and direction.

How easily an object moves (or doesn’t) depends on its weight and the strength of forces acting upon it.

</td></tr>
<tr><td>Follow Up/Practice</td><td>

**Online game- Mini Golf Motion**
Design solutions to mini golf challenges using physics and engineering.
https://ssec.si.edu/mini-golf-motion

**Golf Ball Mystery** (video on USB)
After watching video, students will draw what they think the interior of the box looks like.

*Pairing the game and the video could be useful.

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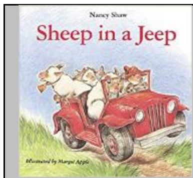
</table>




**Sheep in a Jeep**
*an alternative read aloud (*Newton and Me* is included on the USB)

Read the story aloud, pausing from time to time to invite student participation and comments. Use prompts such as those below to help students explain how forces (pushes and pulls) affect the motion of an object.

- What can the sheep try to get the jeep moving? (*give it a push*)
- How much push do you think the sheep need (little, a lot)?
- What kind of hill were they on? (*Steep*)

Ask student to use their hands to show you what a steep hill looks like. (angle)
Going down a steep hill is like rolling down tall ramp.

- What do you think the steep hill will do to the speed of the jeep? (*cause it to move quickly*)
- When sheep tug, what force are they using? (*pull)*

The jeep is heavy. The sheep need help.

- What force do the pigs use? (*push*)

Oh no! Not the tree.

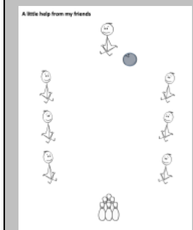
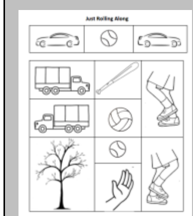
- What is our science word for objects that run into each other? (*collide*)
- How can you explain the forces when the jeep collided with the tree? (*There were two forces. Both were pushes. The tree was more massive and stopped the jeep*.)
- What do you think might have happened if the tree was very small? (*The jeep might have pushed it over and kept on going*.)

Students should have many opportunities to view, describe, and discuss the movement of objects and to identify the forces behind them.

**Playground Field Trip-** Ask students to identify and describe examples of forces on the playground (or around the school).

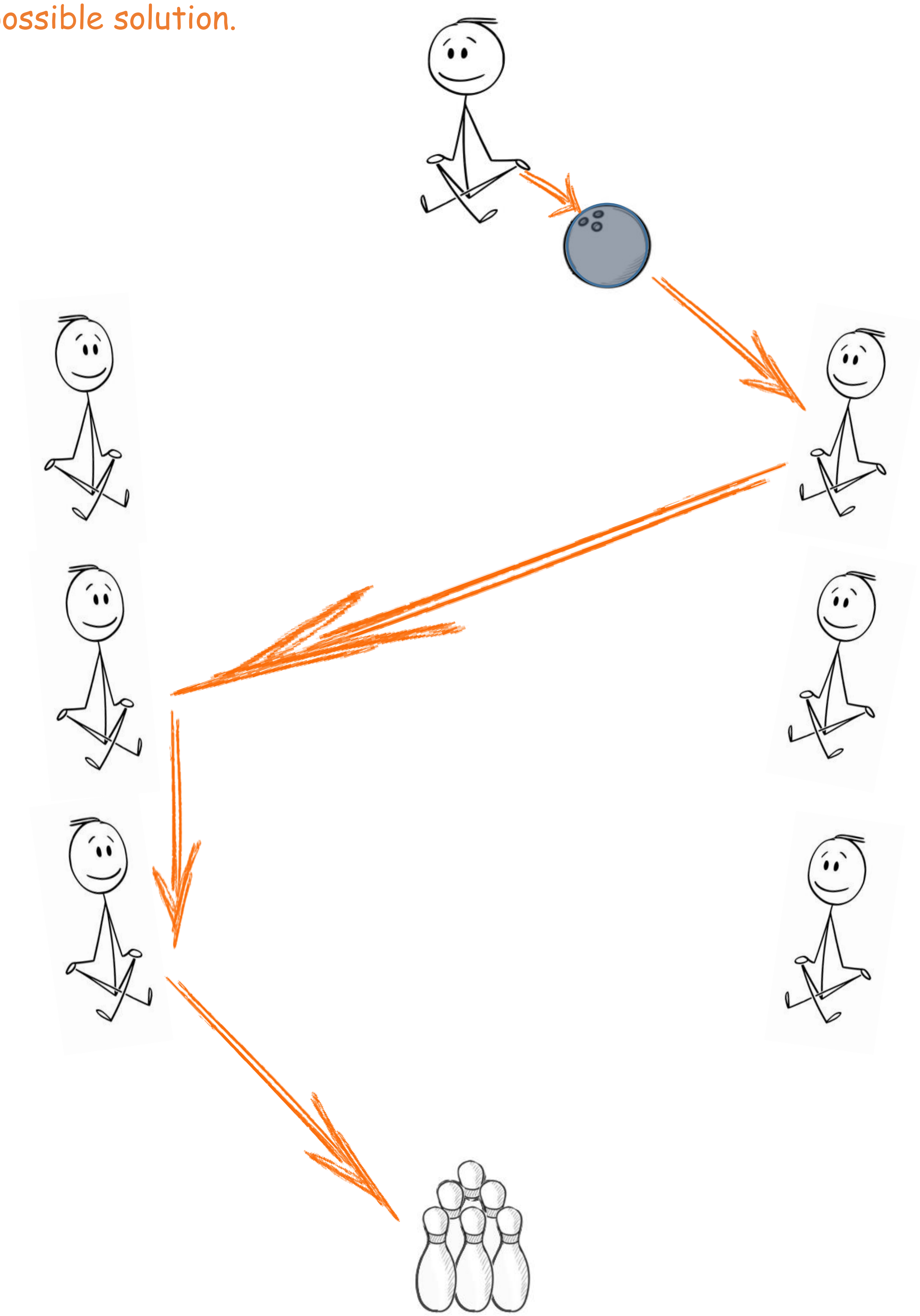
Some examples are:

- Kicking (or throwing) a stationary ball. The force is a push that causes the ball to move away. If you kick hard, the ball will move quickly. If you kick softly, it will move slowly. If you kick hard, it will go far. Soft kick, not as far.
- Pushing someone on the swing. The force is a push away. Lots of pushes added together will cause the person swing faster.
- Catching a moving ball. The force of their hands stops that ball from moving. If that ball is very heavy (like a bowling ball) the force might be too great for a person to stop it with their hands.
- Kicking a moving ball. (There are two forces- the foot against the ball and the ball against the foot-both are pushes). The ball can change or direction in the collision.

| | |
|---|---|
| Assessment<br><br><br> | **A little help from my friends**<br>The student at the top of the page cannot push the ball with enough force to make it all the way to the other end and knock down the pins.<br><br>Use arrows to show a path the ball could take to knock down the pins that includes the help of multiple people.<br><br>Students should be able to answer questions about pushes, pulls, and changes in speed or direction.<br><br>**Just Rolling Along- A Story**<br>Students will choose one object from the first set of boxes.<br>Cut out and color this object.<br>*Only color the object that the story will be about. (ball or car)<br><br>Glue this object on a sheet of paper.<br>Students should then add objects from the other boxes to help tell a force story.<br>Students can draw on the page to help tell the story as well.<br>For example, student may wish to draw a line to show the object on a hill.<br><br>Students should write a few sentences about the pushes, pulls, and changes in speed or direction in their story.<br><br>Students should be able to answer questions about pushes, pulls, and changes in speed or direction.<br><br>**Optional:** students can share force stories with each other. |

**A little help from my friends**

A possible solution.



The student should be able to answer questions about pushes, pulls, and changes in speed or direction above.

| Lesson 5 | Engineering a Solution |
|---|---|
| Overview<br>Standard(s) &<br>Objectives | **Overview**<br>Students will consider how pushes and pulls can cause an object to change speed or direction as they analyze data from tests of two objects designed to solve the same problem. Students will compare strengths and weaknesses of how each design performs. As this unit comes to a close, students will examine push and pull forces at work at the Sanford Underground Research Facility (SURF).<br><br>**Building Toward**<br>**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 pull.*<br><br>**K-2-ETS1-3** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.<br><br>Crosscutting Concept<br>✓ Cause and Effect- simple tests can be designed to gather evidence to support or refute student ideas about causes.<br><br>Science and Engineering Practice<br>✓ Analyzing and Interpreting Data- analyze data from tests of an object or tool to determine if it works as intended.<br><br>**Objectives**<br>Students<br>• Demonstrate, explain, and predict how pushes and pulls can start, stop, or change the direction of an object's motion.<br>• Analyze data from tests of two objects designed to solve the same problem to compare strengths and weaknesses of how each performs. |
| Background<br>Information | **Taking Control**<br>Knowing how and why things move is important because so much of everyday life depends on predicting and controlling motion. We are able to make those decisions because we understand how things move when certain forces act upon them.<br><br>If we push something, it moves away from us. If we pull it, it moves toward us. If we apply a force to a moving object, it will change speed or direction. We can regulate the amount of force used when causing things to move, changing speed, or direction. Knowing how things move allows us to work, play, travel, and complete everyday tasks with confidence.<br><br>**Sanford Underground Research Facility--SURF**<br>The Sanford Underground Research Facility, in Lead, South Dakota, is an underground science laboratory built in the former Homestake gold mine. SURF hosts a variety of science experiments. Some of the largest physics experiments, in dark matter and neutrino research, are located nearly one mile underground (4850 feet) to protect sensitive equipment from cosmic rays that can interfere with their results. |

| | |
|---|---|
| Materials | *For each student:*<br>• Science notebook<br>*For the teacher:*<br>• Chart paper and markers (or whiteboard)<br>• *Video- Mini Golf Physics*<br>• Forces at work pictures (Sanford Underground Research Facility)<br>*For each pair/small group:*<br>• Paddle ball<br>• Bungee ball |
| Prior Knowledge | To cause something to move, sometimes you need a lot of force, sometimes just a little force.<br><br>Once an object is moving, it requires a force to speed up, slow down, stop or change direction. |
| Questions | **Driving Question**<br>• How can forces be used in different ways to solve a problem?<br><br>**Probing Questions**<br>• Once an object is moving, what are some ways we could change its motion?<br>• What effect would a pull have?<br>• What problem you think these objects were design to solve?<br>• What other objects can you think of that solve a similar problem?<br>• What works well? Not as well?<br>• How could you improve the design? |
| Launch (10 minutes) | |
| Engagement and Communication of Student Expectations | During our last exploration we learned a new science term- collide.<br>In a minute I am going to ask you how you would explain *collide* to someone.<br>What I want you to do first is think quietly about your answer. Then I am going to ask you to turn to your shoulder partner and talk about your ideas. Then I'm going to ask a few students to share their explanation with the group. Ready?<br>• What does collide mean? How would you explain it to another person?<br>*Allow 3-5 seconds of <u>personal think time</u>.<br>*Turn to shoulder partner.<br>*Set a timer for 1-2 minutes for partners to share/discuss ideas.<br>*When time is up, ask three students to share out thoughts and ideas from their discussion.<br>*Student responses may vary but should involve two (or more) objects running into each other AND that when objects collide it can change their speed (speed up, slow down, stop) or direction. Collisions can happen quickly or slowly.* |

| | |
|---|---|
| | • How many forces are in a collision? (*One from each object*)<br>**Note:** If students struggle here, you should give a specific example for them to consider- like a ball colliding with a wall.<br>• What types of forces are in a collision? (*pushes from each object*)<br>• What are some examples from our explorations? (*hand stopping car or ball-- two balls or cars colliding, etc*)<br>We have been exploring and learning a lot about forces and how we can cause objects to change speed and direction. Today I have a challenge for you to think about.<br>• Once an object is moving, what are some ways we could change its motion?<br>*Allow 3-5 seconds of <u>personal think time</u> before asking for ideas.<br>*Student responses will very likely revolve around using pushes of some sort to change direction of motion.*<br>• Once an object is moving, what are some ways we could change its motion with a pull?<br>*Student responses may vary but should involve using something like a string or a handle to pull on the object. A common real-life example could be pulling back on the leash to change the speed or direction a pet <u>or</u> pulling on the handle of a cart to change its speed or direction.* |
| Explore (30 minutes) | |
| Procedure<br><br>**Comparing Designs Materials**<br>• Paddle Ball<br>• Bungee Ball | Today we are going to look at two objects that were designed to solve a particular problem.<br>✓ Remind students that they are studying the design of the object. These objects can be studied without using them for their intended purpose. In this case doing so may cause students to become distracted by the need to become proficient in object use, rather than thinking about how and why they work. (Physical testing can be done in part 2, if you choose.)<br>**Pairs or Small Groups**<br>It will be your job to decide what problem you think these objects were design to solve. You will choose <u>one</u> and explain how it works.<br>**This may be lots of writing for very early learners. These questions could easily be used in small or whole group discussion.*<br>1. Draw a picture of each object in your science notebook.<br>2. Carefully investigate each object.<br>• What do you notice?<br>• What do you wonder?<br>3. What problem you think these objects were design to solve?<br>4. Write your answer in your science notebook.<br>5. Choose <u>one</u> object and explain how it works describing the forces in your science notebook. Encourage students to use drawings to help with their explanation. |


**Share**

*The facilitator should act as recorder. Keep a record of student ideas on chart paper or the whiteboard.*

Ask several students to share:

- What do you notice?
- What do you wonder?

Ask several students to share what problem they think these objects were designed to solve. (*a toy that returns a ball so you don't have to chase it*)

- Who need(s) this? Why? (*Anyone could use this! Maybe they are the only person playing, or have a small space where they don't want the ball to get away, maybe it is a challenge for them to go after the ball…)*
- How does it work? (*see example below*)

Encourage students to share drawings to help with their explanation.

As a group discuss the movement of the ball describing pushes, pulls, strength, and direction.

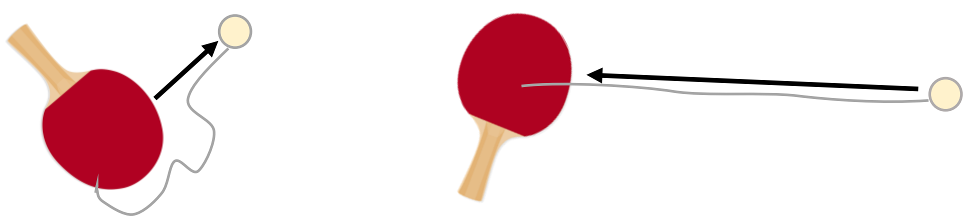
**How does it work? Example**

Paddle hits ball (push)- ball moves away from paddle.

The harder the ball is pushed, the faster it moves away from the paddle.

While ball is moving the string on paddle is tugged (pull)-ball moves toward paddle.

The harder the string is pulled, the faster it moves toward the paddle. (back to person)



**Part 2- Strengths Weaknesses** (30 minutes)

While there is always more than one possible solution to a problem, not every design is perfect. Today you will evaluate the strengths and weaknesses (what works well and what does not) of each design to determine which object is best for the problem you identified.

***Note:*** *Early learners may not be ready to generate a list of strengths and weaknesses on their own. It may be necessary to either brainstorm as a group, or provide an assortment of choices they can select from as they analyze and evaluate different designs. Do leave space for the students to add their own comments. The important thing is to support the students in evaluating designs, so they learn to think analytically.*

**How does it measure up?**
Students will investigate how well (or not well) each of the objects performs its intended performance.

When testing, keep in mind that students' skill level and available space are considerations.

| Strengths (Works well) | Weaknesses (Doesn't work as well) |
|---|---|
| Easy to use | Not easy to use |
| String long enough | String too long/short |
| Well-made | Not well made |
| Ball returns | Ball does not return |
| Fun | Not very fun |
| ……. | ……. |
| ……. | ……. |

1. In your science notebook, identify strengths and weaknesses for each object.
2. Circle the object you think has the best design.
3. Be prepared to explain your choice.

**Group Discussion**

- What problem were these objects designed to solve? (*a toy that returns a ball so you don't have to chase it*) (a ball game you can play on your own)

One of our jobs was to decide which object had the best design.
Let me see a thumb up if you think the paddle ball is the best design.
Select a student (or two) to explain why they believe it is the best design.

Let me see a thumb up if you think the bungee ball is the best design.
Select a student (or two) to explain why they believe it is the best design.

- What other objects can you think of that solve a similar problem? (*yo-yo, tether ball, skip ball, etc*)

Summarize (10 minutes)

Communicate

I am learning so much about forces and how they can help us get things done! Both paddle ball and bungee ball can be fun games, but they don't require the person using them to move very far. I'd like to think back to the mini golf video from the beginning of the unit. In mini golf the player (and the ball) move around a lot more.

- What causes all that movement? (*forces- pushes and pulls*)

We are going to watch the mini golf video again, and I want you to watch for evidence of forces acting on the golf ball.

- What does evidence mean? (*proof- a sign which shows that something exists)*
- How will we know when we see evidence of a force? (*the ball will start or stop moving- the ball will change speed or direction*)

We should have a code word for each time we see evidence of a force in the video. Our code word needs to be short so I know when to stop the video to share.

Code word = ___________ (*now*, for example)

Show the video, **Mini Golf Physics** (first 30 seconds only) to students. On USB or https://www.yout-ube.com/watch?v=GygGhvcAaPw

*The facilitator should be prepared to stop the video each time the code word is used.*

**Some evidence of forces that student might recognize.**

- The putter caused the ball to begin moving. *(a push away)*
- The ramp caused the ball to go into the air. *(a push away)*
- The ramp caused the ball to go faster. *(a push away)*
- The ball collided with the edges of the trough and changed direction. *(pushes)*
- The ball rolled into the hole and changed directions. *(a push away)*
- The ball curved on the ramp. *(a push away)*
- The cup stopped the ball. (*two pushes- just like catching a ball with your hands.)*

Part of what makes this game so fun is that we can predict the movement the ball!

- What choices do we get to make? (*where to aim- which direction the ball will move AND how much force to use*)
- What are we deciding when we chose how much force to use? *(Distance-Speed--Lots of force causes the ball to go farther/faster. Little force causes the ball to move a shorter distance and more slowly)*
- Is a golf ball light or heavy? (*light*)
- Does that make it easier or harder to change its movement? (*easier*)
- How would the game change if we used a bowling ball instead of a golf ball? (*It would take lots of force to cause a bowling ball to start moving. You might need something bigger than a putter. It would be difficult to change the speed or direction of a bowling ball. The bowling ball could break the obstacles it collides with. It would be difficult to stop the bowling ball.)*

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**Part 3- Forces at Work** (30 minutes)

So far we have discussed using forces to play games and complete everyday tasks, both at home and school. We have one more situation to think about…at work.

- What are some objects at work that people might need to move? *(Student responses will vary depending on the kind of occupation they imagine, but should a variety of objects)*

***Note***: *If students struggle, it might be helpful if you suggested an occupation, then asked students what objects they might need to move. Some examples- construction worker, nurse, teacher, police officer, scientist, farmer, chef, fire fighter…..*

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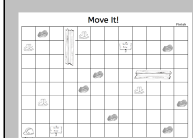
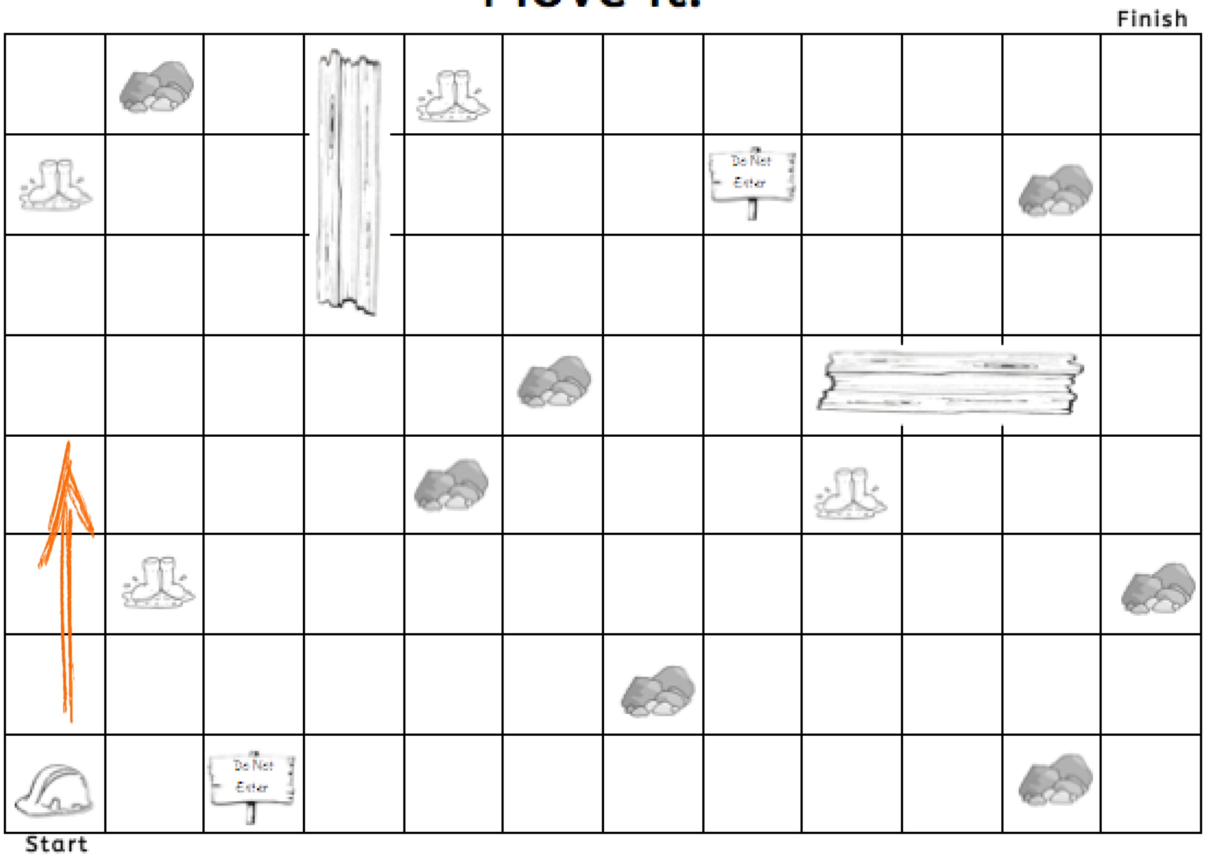
<td>
</td>
<td>
The facilitator should act as recorder. Keep a record of student ideas on chart paper or the whiteboard.
<ul>
<li>How could we divide these objects into two groups? (likely responses include heavy/light, big/little, needs a lot of force/little force)</li>
<li>Why are some objects easier (or more difficult) to move than others? Student responses may vary, but should suggest the idea that heavier things are harder to move. Lighter things are easier to move. (To cause something to move, sometimes you need a lot of force, sometimes just a little force.)</li>
<li>What do we need to do differently if we need to move something very heavy? (use more force, get help from more people)</li>
</ul>
I have some forces at work pictures from the Sanford Underground Research Facility. We are going to look at the pictures and discuss the objects that need to be moved and the forces needed. (ppt on USB)
<ul>
<li>What types of forces are being used? (Identify pushes and pulls)</li>
<li>How easily (or not) do you think the object will move? Why?</li>
<li>Which direction will the object move?</li>
</ul>
Move It Obstacle Course<br>
Students will visualize the forces necessary to move a hard hat to the finish of an obstacle course. Along the way they will consider both strength and direction.
This version represents the underground and can be found in their science notebook.
</td>
</tr>
<tr>
<td>Terminology and Concepts to Solidify</td>
<td>
Analyze- Examine something carefully to explain or interpret
Designed- planned and created for a particular purpose
Evaluate- to judge the quality
Evidence- a sign which shows that something exists
Strengths- what works well
Weaknesses- what doesn’t work as well
</td>
</tr>
<tr>
<td>Connection to Big Ideas (Phenomena)</td>
<td>
A force has both strength and direction.
How easily an object moves (or doesn’t) depends on its weight and the strength of forces acting upon it.
We cannot see a force, just its effects. A change in the motion of an object indicates that a force is acting on it.
The movement of objects can be described, and even predicted, because no matter what is moving it will always start, stop, or change direction according to certain rules.
</td>
</tr>
</table>

| | |
|---|---|
| Follow Up/Practice | **Paper Plate Marble Maze**<br>https://buggyandbuddy.com/paper-plate-marble-maze/<br><br>Creating the maze requires some planning, as students will have to decide where the start and end of their maze is. You may wish to have students design their maze on a piece of paper first.<br><br>**Fish Force**<br>https://pbskids.org/ruff/games/fish-force<br>Predict and investigate forces and motion to help rescue Ruff's plushie from the penguins' ice rink. Use the arrow keys to change the force and adjust the cannon position.<br><br>**Just for fun—Madagascar- Move It!** (music)<br>Audio/video file can be found on the unit USB<br><br>**Bring the Sanford Underground Research Facility into your school or classroom!**<br>Invite an Education and Outreach team member to visit your school, they will talk about SURF, share pictures and video, as well as answer questions from students. Our programs are available to schools across South Dakota, free of charge.<br>https://www.sanfordlab.org/educators/school-presentations |
| Assessment<br> | **Functional Forces**<br>Choose a task you do every day that requires forces to get the job done.<br>• Draw a picture of the task.<br>• Think about each step and identify each time a force is needed.<br>• How much force is needed?<br>• Use descriptive words to explain what is happening. |

# Move It!




**Move It Obstacle Course Directions**

- Find the hard hat at the start.
  Your goal is to create a path to move the hard hat through the obstacle course to the finish.
- Decide which direction you are going to go.
- Decide the strength of the force you are going to use.
- Draw an arrow to represent your first move.
  An example of a medium force is above.
  The maximum number of squares for one move is five.
- Plan your next move (direction and strength)
- Draw an arrow to represent your next move.
- Repeat until you reach the finish line
- Each arrow represents 1 move. Count the number of moves it took to get the hard hat to the finish.

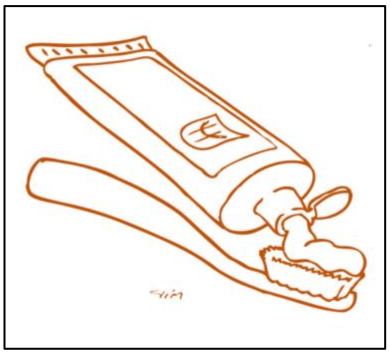
**Extension:** Try again, in different color to see if it can be done in fewer moves.
**Or** use the blank grid in the print masters to design your own mini golf obstacle course.

# Functional Forces

Name ____Your Student____________

Choose a task you do every day that requires forces to get the job done.

- Draw a picture of the task.
- Think about each step and identify each time a force is needed.
- How much force is needed?
- Use descriptive words to explain what is happening.



Brushing My Teeth

- I pull open the cabinet.
- I pull the toothbrush and toothpaste from the holder.
- I gently push the cabinet closed so it does not slam.
- I carefully push on the tube so too much toothpaste does not come out.
- I push and pull to brush my teeth.

**Everyday task ideas-- push or pull? With how much force?**
Eating a meal- Pass the salt- cut meat- use a fork
Getting dressed- Open/close doors, drawers, lids- put on socks

Technology- Turn on/off device-click a mouse/type

Use whiteboard-Take the cap off a marker/write/put cap back on

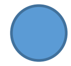
Chores- sweep- take out trash- clean a room- rake- pull weeds-

Play a game- Kick or catch a ball

Creating art- Use a glue stick, scissors, or crayon

# Print Masters

# Cause and Effect

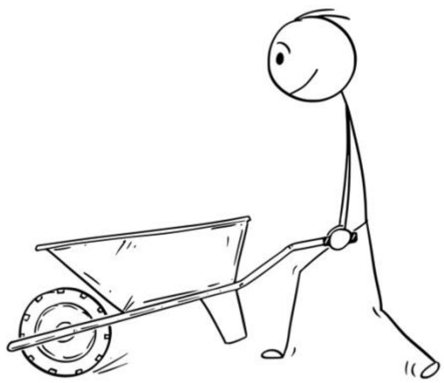
| If you… | (Cause) | object | (Effect) |
|---|---|---|---|
|  kick a ball | (Push) |  the ball | (moves away) |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# Push Pull Forces

Name ________________________________

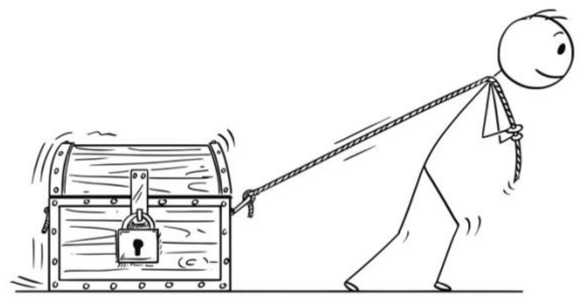
1. Draw an arrow on each picture to <u>show</u> the direction the object will move.
2. Write **push** or **pull** on the line to <u>tell</u> the type of force.

Which direction will the **wheelbarrow** move?



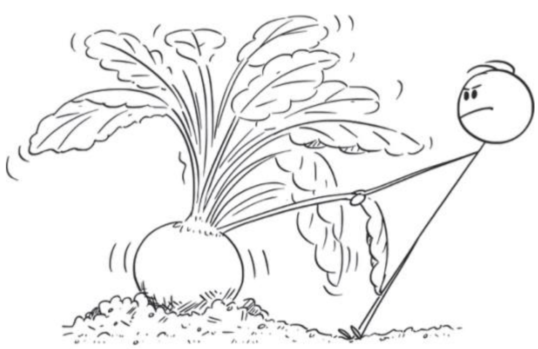
__________________________________

Which direction will the **treasure chest** move?



__________________________________

Which direction will the **radish** move?



__________________________________

Which direction will the **button** move?

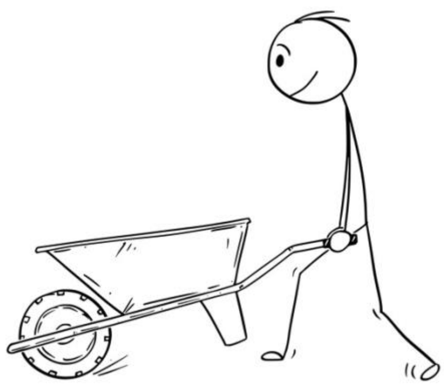
__________________________________

# Push Pull Forces

Name________________________________

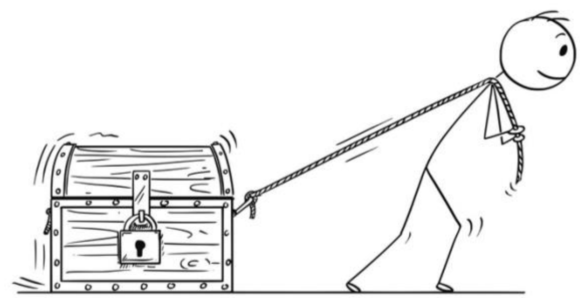
1. Draw an arrow on each picture to show the direction the object will move.
2. Circle either **push** or **pull** to tell the type of force.

Which direction will the **wheelbarrow** move?



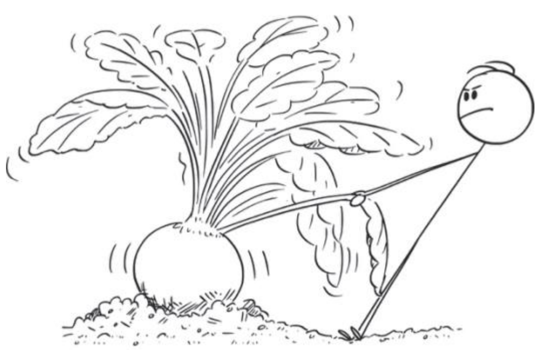
**Push** **Pull**

Which direction will the **treasure chest** move?



**Push** **Pull**

Which direction will the **radish** move?



**Push** **Pull**

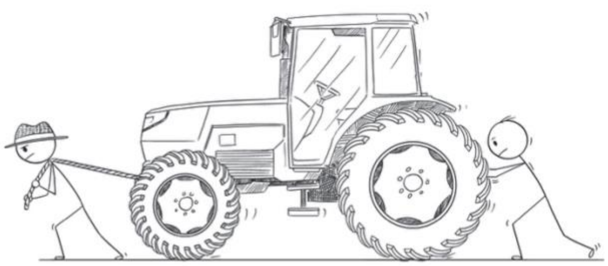
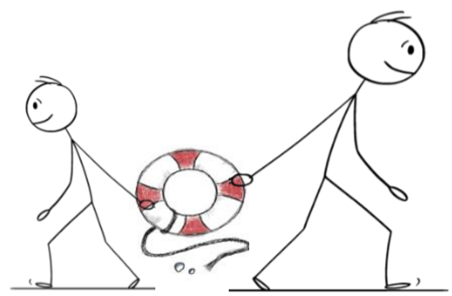
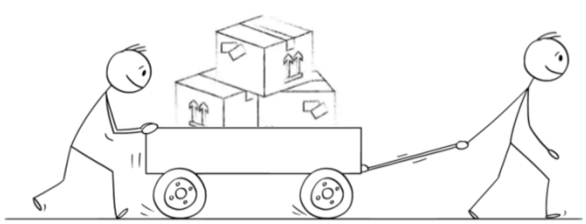
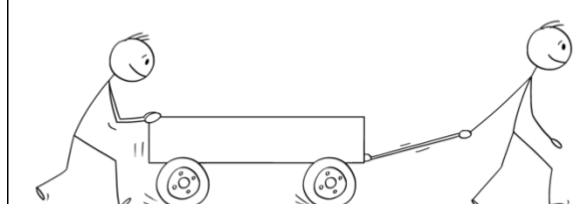
Which direction will the **button** move?

**Push** **Pull**

# Push Pull Forces (Multiple)

Name ______________________________

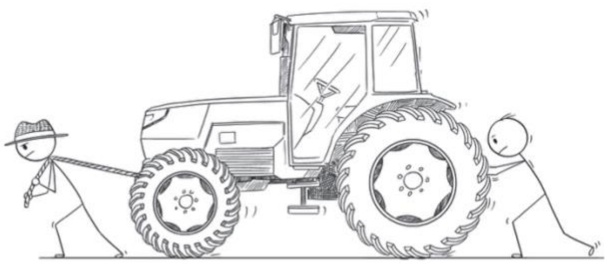
1. Draw arrows on each picture to <u>show</u> the forces.
2. Will it take a **lot** of force or a **little** force to move the object?

| | |
|---|---|
| <br>______________________________ | <br>______________________________ |
| <br>To move heavy objects,<br>____________ force is needed. | <br>To move ______________objects,<br>less force is needed. |

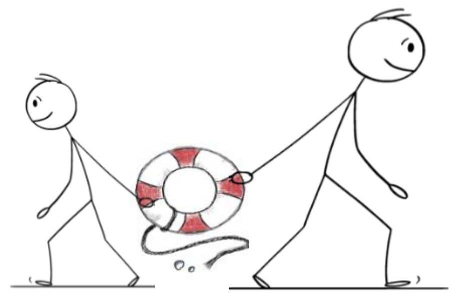
# Push Pull Forces (Multiple)

Name ________________________________

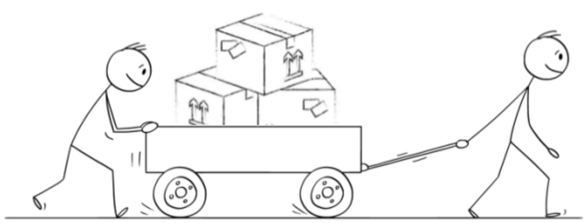
1. Draw arrows on each picture to <u>show</u> the forces.
2. Will it take a **lot** of force or a **little** force to move the object?



**Lot** **Little**



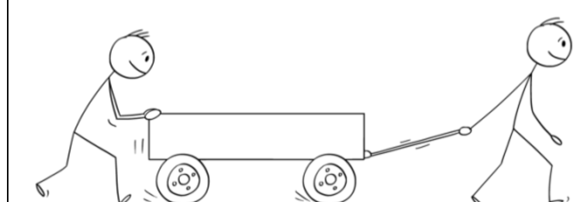
**Lot** **Little**



To move heavy objects,

| |
|---|
| less<br>more |

force is needed.



To move

| |
|---|
| light<br>heavy |

objects,

less force is needed.

# Going the Distance

Name ________________________________

You've been asked to design new slides for the playground!

Your manager wants two kinds of slides. Draw your designs below.

| |
|---|
| For people who want to go **fast**. |
| For people who want to go **slow**. |

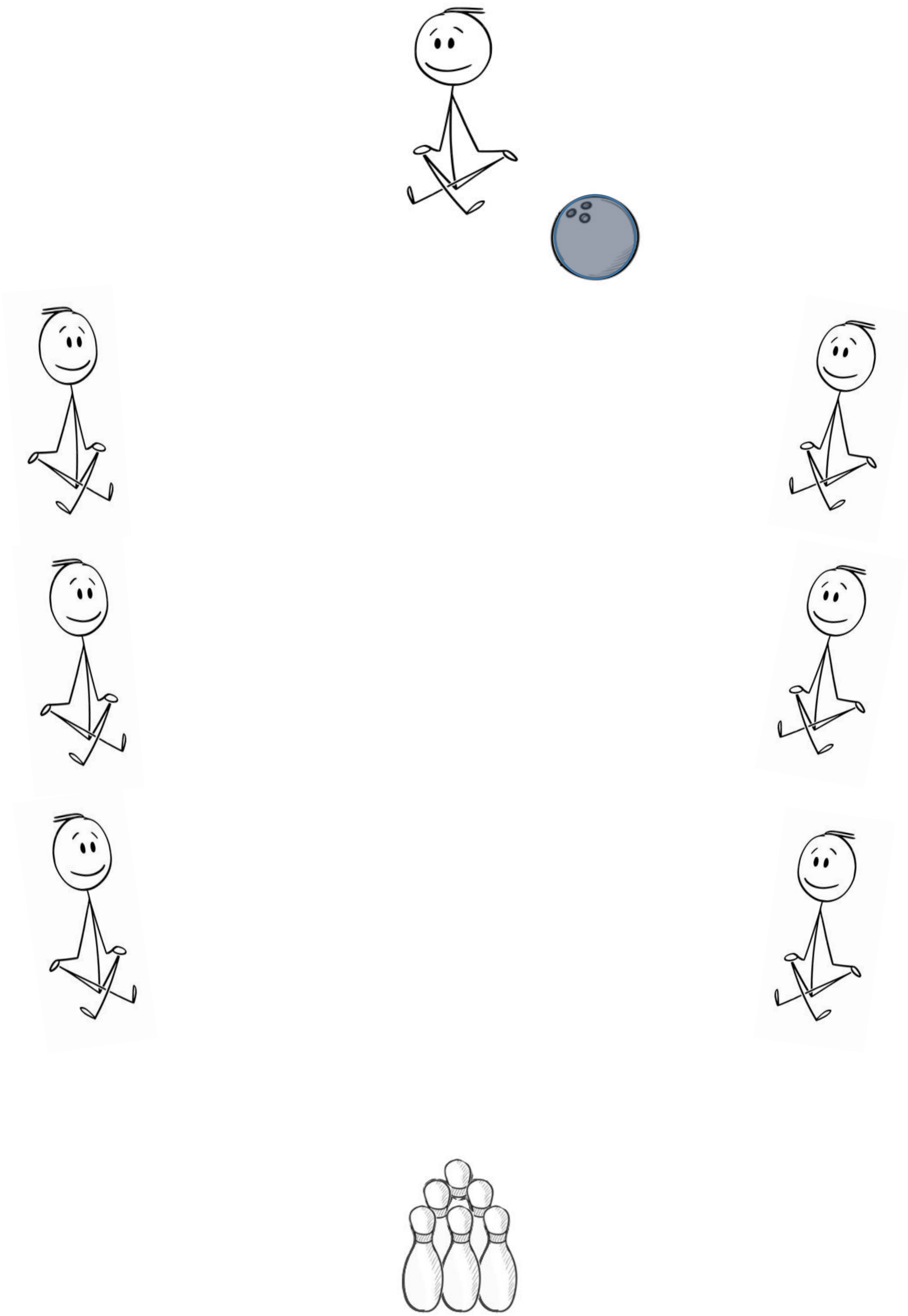
**What is different?**

# Going the Distance

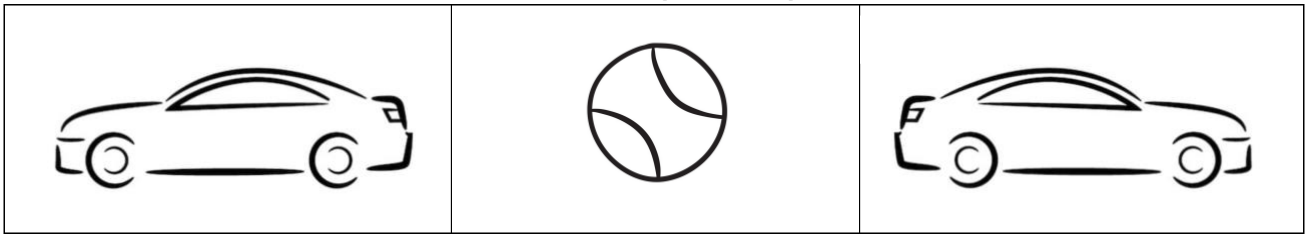
Name________________________________

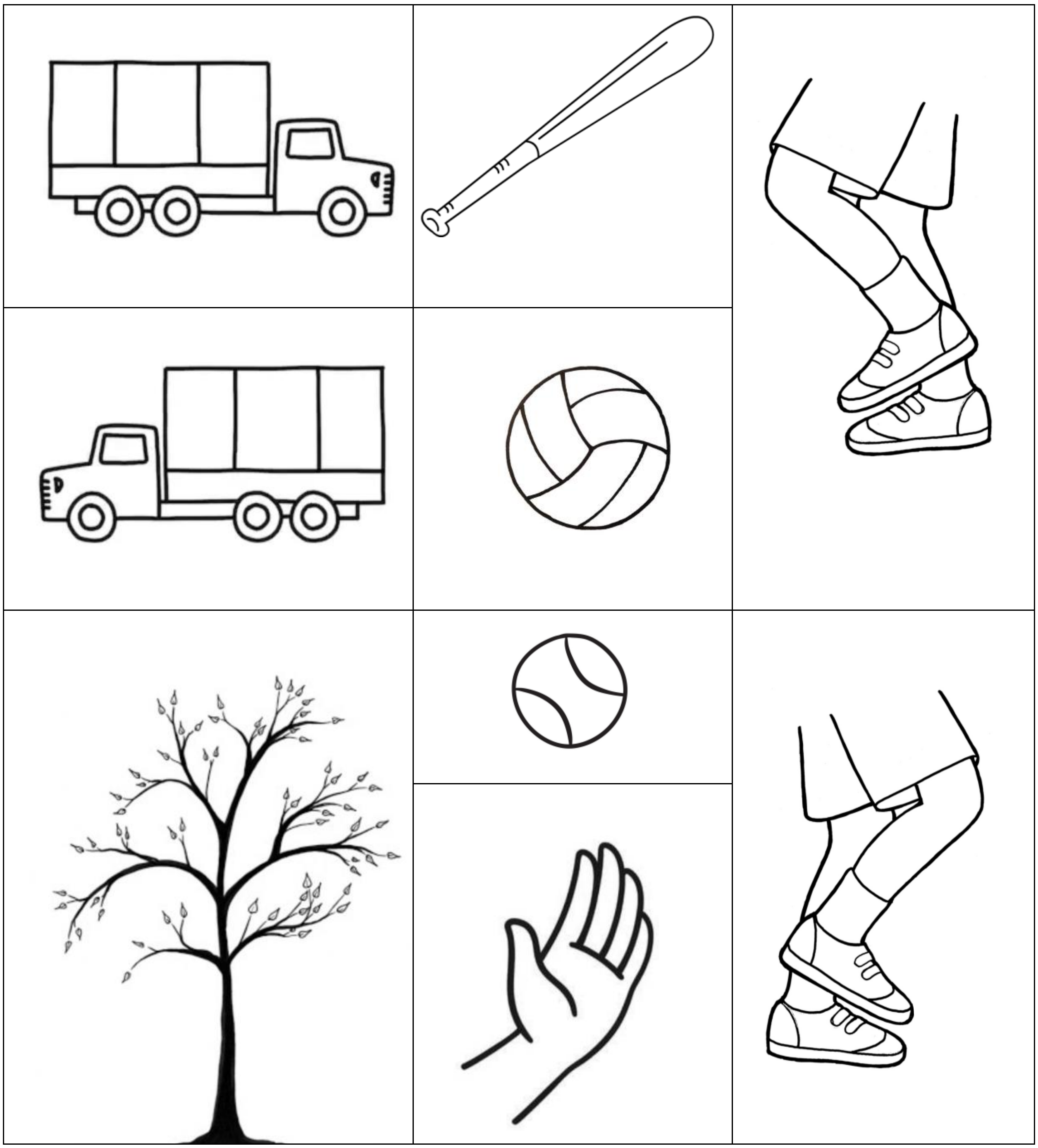
- What advice would you give Taylor if the goal of the game was to get the bean bag in bucket #5?
- What about bucket #3?

## A little help from my friends



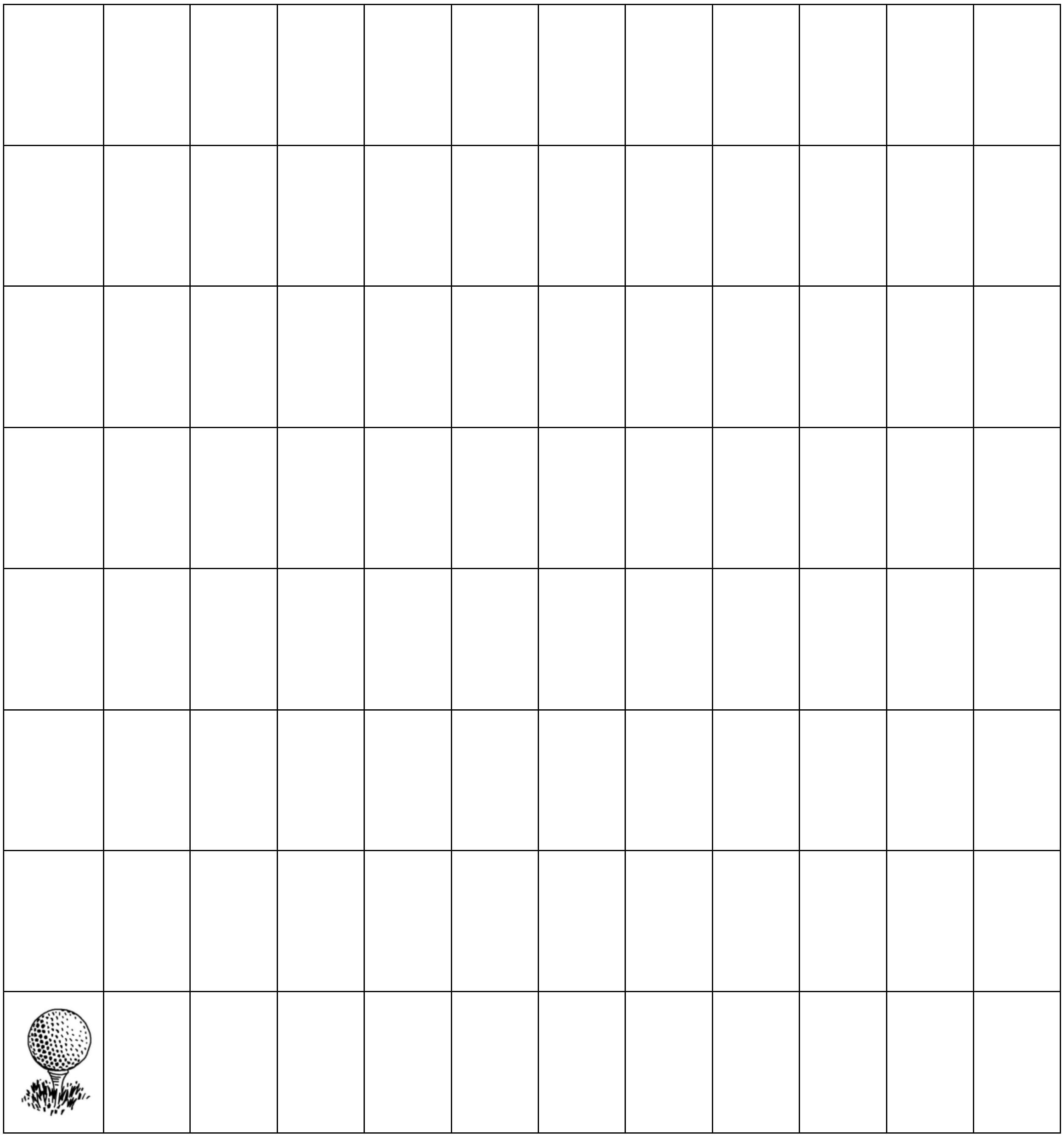
# Just Rolling Along





# Move It!

**Finish**



**Start**

Add obstacles to your course.

Challenge a friend to complete the course with as few strokes as possible.

# Functional Forces

Name ________________________________

Choose a task you do every day that requires forces to get the job done.

- Draw a picture of the task.
- Think about each step and identify each time a force is needed.
- How much force is needed?
- Use descriptive words to explain what is happening.

## Performance Rubric

How do FORCES (pushes and pulls) affect the MOTION of an object?

| | Evidence for Exceeding Expectations | Meets Expectations | Areas for Improvement |
|---|---|---|---|
| **L1** | | Can differentiate between push and pull forces.<br>Can describe the direction of pushes and pulls. (away, toward)<br>Can predict the direction an object will move with a push or pull. | |
| **L2** | | Can explain that to move heavy objects, greater force is needed.<br>Can explain that to move light objects, less force is needed.<br>Can model balanced and unbalanced forces. (equal- not equal) | |
| **L3** | | Can demonstrate that varying the amount of force applied to an object will affect the motion (speed/distance) of an object.<br>Can explain that harder pushes or pulls will cause an object to move farther/faster than soft pushes or pulls. | |
| **L4** | | Can explain that when objects collide, an object's motion (speed or direction) can be changed.<br>Can demonstrate and explain that heavier objects are harder to start/stop/re-direct than lighter objects. | |
| **L5** | | Can compare two objects designed to solve the same problem and tell you the strengths and weaknesses of both.<br>Can explain that forces can be used to solve problems because they can cause objects to start, stop, change direction or speed according to certain rules. | |