THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Rubber Band Races

How does the size of a rubber band affect how far it can push a marble?

GRADE K

Physical Science

VAN ANDEL EDUCATION INSTITUTE
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INQUIRY-BASED SCIENCE

Physical

Rubber Band Races

Grade Level/Content	K/Physical Science
Lesson Summary	Students explore the relationship between forces and motion as they use different sizes of rubber bands to move marbles.
Estimated Time	1, 45-minute class period
Materials	rubber bands in three (or more) different sizes, marbles (identical size), 2 unsharpened pencils, ruler or measuring tape, carpeted area, Investigation Plan, Observation Form, journal
Secondary Resources	*Forces Make Things Move* by Kimberly Brubaker Bradley *Give It a Push! Give It a Pull!: A Look at Forces* by Jennifer Boothroyd *Motion: Push and Pull, Fast and Slow* by Darlene R. Stille
NGSS Connection	**K-PS2-1** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
Learning Objectives	• Students will describe the relative strengths of a rubber band's force applied to a marble. • Students will provide evidence of how the strength of the force of a rubber band affects the motion of a marble. • Students will collect data comparing the effect on a marble caused by changes in the strength of the force of a rubber band.
Cross-Curricular Project Connections	Rubber Band Racers, Smooth Sailing

How does the size of a rubber band affect how far it can push a marble?

Forces can be either pushes or pulls. A force can change the motion of an object in different ways. It can make an object start moving, stop moving, or change speed. A force can also change the direction in which an object moves.

In this hands-on activity, students will use rubber bands to move a marble across the carpet. They will discover how the strengths of forces on an object relate to the object's motion. Then, each group of students will host a rubber band race, like the races on television, acting as both the pit crew and the television commentators by explaining the reasons why one rubber band pushes the marble farther than the other one.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Divide the class into teams of 3. Display the rubber bands with labels that indicate the size number (1, 2, 3, for example) for each size. Have students write the size numbers on their **Observation Form** for comparison. Students will need the following materials:

- rubber bands in three (or more) different sizes
- marbles (identical size)
- 2 unsharpened pencils
- ruler or measuring tape
- Investigation Plan
- Observation Form
- carpeted area

Note that a small size difference between the rubber bands used in the trials may yield a narrow range of results that could be difficult for kindergarten students to observe and interpret. Use rubber bands of greatly varying sizes for a broader range of results that will be easier to observe and interpret at this age.

Arrange for students to conduct the investigation in a large, carpeted area. You may prefer for students to roll the marbles along a track. Either set up tracks beforehand by taping meter sticks side-by-side, about six inches apart, or have students design and construct a track. Another option is to have students bring in plastic race car tracks from home.

STUDENT CHOICE

Encourage students to collaboratively contribute to the development of the investigation plan. You may want to change out the materials used in the investigation if the class collectively has an idea for different materials that can be used to answer the same investigation question.

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

How does the size of a rubber band affect how far it can push a marble?

CRITICAL THINKING

Students may assume a rubber band cannot exert a strong force because it is so flexible. Ask them to consider how a rubber band can be used to exert a strong force. Explain that stretching a rubber band gives it more energy as long as you do not stretch it enough to break it. It can use this extra energy to exert a stronger force on objects.

Personal Knowledge

Students capture what they already know about rubber bands, marbles, forces, and motion.

- After asking the Investigation Question, introduce the materials. Divide the students into groups of three.
- Ask students to talk about what they already know about these materials. Then, have them talk about what they know about forces and motion.
- After students share their knowledge in their group, pair each group with another for a wider discussion. Sample answers may include: *marbles roll when you hit them, rubber bands break when you pull too far, thick rubber bands are stronger, etc.*

Prediction

Students communicate an expected outcome, based on prior knowledge.

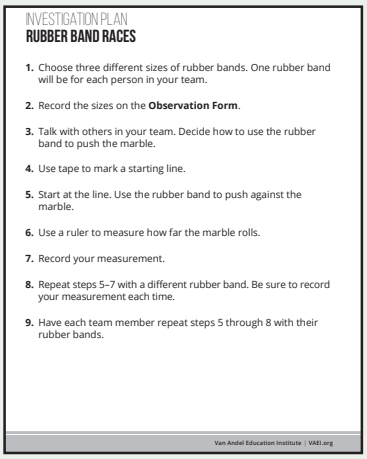
- After each student in the class has had a turn to share their knowledge with several class members, bring the discussion back to the materials. Explain to students that they will be using the rubber band to push against the marble. Point out the different sizes of rubber bands. Ask students to consider what will happen.
- Ask students to draw in their lab journal what they predict will happen when they use the different sizes of rubber bands to push against the marble.
- Once students record their predictions, allow them to share their ideas within their small group.

Investigation Plan

Students conduct trials to determine how the size of a rubber band affects how far a marble can travel.

Introduce the investigation:

- Hand out the materials to each group. Display the Investigation Plan and review it as a class to prepare students for the investigation.
- Each group will have to decide how to use the rubber band to push the marble. One method is to hold two pencils in place on the floor to use as a free-form slingshot by wrapping the rubber band around the pencils. It takes three students to make this free-form slingshot method work. One student holds the left pencil in place while the other holds the right pencil in place. The third student works with the rubber band and the marble. To make the marble move, the third student places it between the pencils on the rubber band and pulls the rubber band back. This pulling motion gives the rubber band potential energy. After the student lets go of the marble, the rubber band pushes the marble forward. The advantage of the free-form slingshot is the ability to move the pencils closer or farther apart to accommodate the varying rubber band sizes. With trial and error, students will discover that placing the rubber band at floor level is the most effective method for pushing the marble.
- As you circulate among the groups, point out that the size of the marble is the same in each trial but the size of the rubber band changes. Discuss with students how they think the size of the rubber band relates to the force it exerts on the marble.



INVESTIGATION PLAN

RUBBER BAND RACES

1. Choose three different sizes of rubber bands. One rubber band will be for each person in your team.
2. Record the sizes on the **Observation Form**.
3. Talk with others in your team. Decide how to use the rubber band to push the marble.
4. Use tape to mark a starting line.
5. Start at the line. Use the rubber band to push against the marble.
6. Use a ruler to measure how far the marble rolls.
7. Record your measurement.
8. Repeat steps 5–7 with a different rubber band. Be sure to record your measurement each time.
9. Have each team member repeat steps 5 through 8 with their rubber bands.

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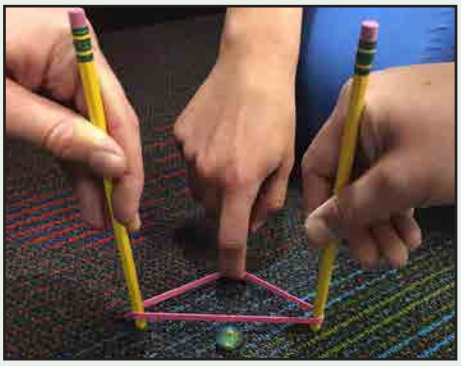
Investigation Plan



Free-form Slingshot Method

PERSEVERANCE

The first challenge that students will face is how to make the rubber band push the marble with these materials. Encourage students to not give up and keep trying until they find a method that works consistently.

INTEGRITY

Remind students to be aware of their surroundings and not to push any marbles across the carpet toward an area where other students are working. If needed, you may also need to remind students not to shoot rubber bands at classmates.

CRITICAL THINKING

Use the Fair Test checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they can be in their results.

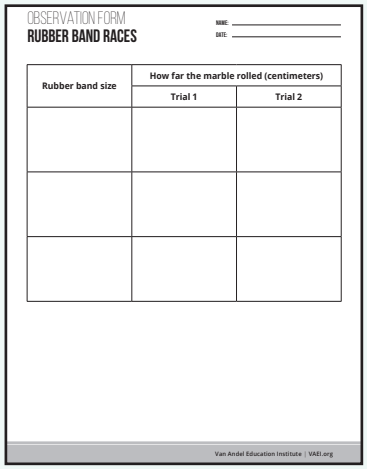
Observation

Students record the rubber band size and how far the marble moved in two trials for each size of rubber band.

- Instruct students to use the Observation Form to record their measurements and other observations. Have students conduct 2 trials for each rubber band size. Each student in the group will be responsible for conducting the trial and recording the results of one rubber band size.
- Observations will depend on the rubber bands that students use. In general, when stretched the same distance, large, thick rubber bands will likely exert a stronger force. However, variations in the rubber bands may affect their ability to easily stretch.

CRITICAL THINKING

Deciding how to measure the distance that the marble traveled is another challenge that the students will face. Will the starting point of each measurement be made from the location of the slingshot? Or will the students include how far back they pulled the rubber band?



OBSERVATION FORM
RUBBER BAND RACES

NAME: _____
DATE: _____

Rubber band size	How far the marble rolled (centimeters)	
	Trial 1	Trial 2

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Observation Form

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM

Data Analysis

Students make sense of their data by organizing it and representing it visually.

Have students analyze their data. They may wish to use the Data Analysis prompt as a guide.

- Have students **evaluate** their data for trustworthiness. If you observed students making different decisions about where to begin measuring, ask them about how this affects the idea of a fair test. (Comparing measurements taken from different starting points is not an equal comparison.)
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. Reinforce math concepts by having students compare numbers, using greater than and less than.
- Have students **interpret** what the identified patterns or trends mean.
- Some students may need help comparing their measurements and relating the size of the rubber band to the strength of the force. Engage them in small-group discussions of the results.
- Ensure they have enough data that it can be used as evidence to support a claim.

Secondary Knowledge

Students use secondary sources to understand how the size of a rubber band can affect how far a marble can travel.

Forces Make Things Move by Kimberly Brubaker Bradley

Give It a Push! Give It a Pull!: A Look at Forces by Jennifer Boothroyd

Motion: Push and Pull, Fast and Slow by Darlene R. Stille

Continued

After reviewing these three picture books about forces and motion, students should have the vocabulary they need to talk about the science in their investigation.

Students should understand that the materials they used in their investigation generated both a push and a pull. When students pulled back the rubber band, their hand transferred potential energy to the rubber band. After students released the rubber band, that energy was transferred to the marble with a push. The potential energy changed to kinetic energy, the energy of movement. The marble moved forward with kinetic energy.

When students changed the size of the rubber band in each trial, the amount of energy they transferred to the rubber band changed. The amount of energy depended on the size and thickness of the rubber band, and how hard it is to stretch the rubber band. A large, thick rubber band requires more energy to pull back, so more energy is transferred to the rubber band. Changing the width and/or the size of the rubber band affects the amount of energy it can transfer.

OPENNESS TO NEW IDEAS

As students discuss the science behind the investigation, connect their learning to the predictions made earlier. As needed, instruct students to be open to new ideas. Explain that scientists have to be open to new ideas if they expect to make new discoveries.

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to develop an explanation that answers their investigation question. Students may wish to use the Explanation prompt as a guide.
- Have students develop a **Claim** to answer the question: How does the size of a rubber band affect how far it can push a marble?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the observations and data obtained from this investigation, as well as science principles they have learned.

Claim

A large, thick rubber band pushes the marble farther.

Evidence

We measured how far each rubber band pushed the marble. The large, thick rubber band pushed the marble 35cm. The small, thin rubber band only pushed the marble 10cm.

Reasoning

Investigation: We used three different sizes of rubber bands to push the marbles. We pulled the rubber band back the same distance for each size. We measured how far each marble rolled. The biggest rubber band pushed the marble the farthest.

Science: The bigger the rubber band, the more energy it has.

Evaluation

Students reflect on the investigation.

- Ask students what surprised them about their measurements and observations.
- Ask students to think about their investigation and to describe one thing they would do differently if they performed the investigation again. Encourage students to explain their choice.

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate understanding of how the size of a rubber band affects how far it can push a marble by describing and comparing two different rubber bands by their measurable physical attributes.

Use role-playing and ask each group to host a rubber band race between two rubber bands of different sizes for the class sitting in the "stands" around the "race track" on the carpet. Before the race begins, the students in each group will prepare their script. Just as they do at the races on television, the members of the "racing team" will talk about each of their rubber band racers by describing and comparing the measurable physical attributes of two different rubber bands. Then, the racing team will demonstrate the force of each rubber band by using it to push the marble forward and measuring the distance the marble traveled for each rubber band. For the post-race show, each team will directly compare two different rubber bands by describing how their physical attributes allow them to gain different amounts of potential energy that transferred to the marble with pushes of different strengths. The audience in the stands around the track will ask the team questions.

Assessment

- For a **formative assessment**, after students read the books in the secondary resources, ask them to describe the movement of the rubber band using science words such as *push, pull, force*, and *motion*.
- For a **summative assessment**, use the rubber band race to evaluate students' understanding of the concepts.

Evaluate each group's explanation on how well students:

- describe the relative strengths of a rubber band's force applied to a marble.
- provide evidence of how the strength of the force of a rubber band affects the motion of a marble.
- collect data comparing the effect on a marble caused by changes in the strength of the force of a rubber band.

Extension

Have students work with their groups to consider how they can use the same setup for the investigation except test the effect of changing the direction of the force instead of the strength of the force.

Take This Lesson Across the Curriculum

Rubber Band Racers

Students add potential energy to rubber bands by twisting them to power race cars made with recycled materials.

Reading/Language Arts	Math	Science	Social Studies
Add Wheels Students read and discuss *And Everyone Shouted, "Pull!": A First Look at Forces and Motion* by Claire Llewellyn. CCSS.ELA-LITERACY.RI.K.2	**Twist and Count** Students count the number of times they twist the rubber bands to power their rubber band cars. CCSS.MATH.CONTENT.K.CC.B.4	**Carmakers** Students design and build rubber band race cars with recycled materials. NGSS: K-PS2-1	**Teamwork** Students work together to determine the duties of each member of their racing team. NCSS: D2.Civ.11.K-2

Smooth Sailing

Students make simple boats and add rubber bands to power them.

Reading/Language Arts	Math	Science	Social Studies
On the Water Students read and discuss *Busy Boats* by Tony Mitton. CCSS.ELA-LITERACY.RI.K.2	**Wind Me Up!** Students count the number of times they twist the rubber bands to power their boats. CCSS.MATH.CONTENT.K.CC.B.4	**Just Add Water** Students design and build rubber band boats with recycled materials to sail in the classroom water table or a portable kiddie pool. NGSS: K-PS2-1	**Wear Your Life Vest** Students share water safety tips and reasons they always wear a life vest when going out onto the water in a boat. NCSS: D2.Civ.3.K-2

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

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