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Spheres on a Roll

by Carol S. Gossett

Topic
Motion

Key Question
How does the mass of different spheres affect the distance they roll when given equal pushes?

Focus
The students will measure and record the direction and distance a variety of spheres roll when given an equal push.

Guiding Documents
Project 2061 Benchmarks
- *Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.*
- *The way to change how something is moving is to give it a push or pull.*

NRC Standard
- *The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.*

NCTM Standards
- *Collect, organize, and describe data*
- *Understand the attributes of length, capacity, weight, area, volume, time, temperature, and angle*
- *Make and use estimates of measurement*
- *Make and use measurements in problem and everyday situations*

Math
Measurement
  linear
  mass
Data organization

Science
Physical science
  force and motion

Integrated Processes
Observing
Contrasting and comparing
Communicating
Generalizing

Materials
For each group of students:
  two spheres (see *Management 1*)

For the class:
  linear measuring tools (see *Management 3*)
  Roll Starter (see *Management 5*)
  masking tape

Background Information
The American Association for the Advancement of Science in the publication *Benchmarks for Science Literacy* states that,

> Young learners should gain varied experiences in getting things to move or not to move and in changing the direction or speed of things that are already in motion. Do they move in a straight line? Is their motion fast or slow? How can you tell? The questions count more than the answers, at this stage. And students should gain varied experiences in getting things to move or not to move and in changing the direction or speed of things that are already in motion.

In this activity the young learners will compare the direction and distance traveled by spheres with differing masses when each are given an equal push to begin to roll. The students are asked to apply measurement and data organization skills. The young learners will discover that spheres roll, and for the most part will roll in a straight line. They will also discover that the sphere's mass has an effect on the distance it will roll given a certain amount of force to begin the movement.

This activity is one of several which can be used to help the young learner begin to construct their understanding of one of the laws of force and motion — *given an equal force, the object with the smaller mass will travel farther than the object with the larger mass.*

On the adult level this understanding is explained using the formula: **force = mass • acceleration**. To exemplify this, think of the *Roll Starter* as the source of this force. For purposes of illustration, we'll assign a value of 12 as the measure of **force** (the push) that is exerted on the spheres. We'll also assign a value of four grams as a measure of the **mass** of one of the spheres we are rolling. The acceleration is represented by a combination of the distance the sphere travels in a measured amount of time. For this example, the **acceleration** is three. In applying the formula we now have: 12 (force) = 4 (mass) X 3 (acceleration).

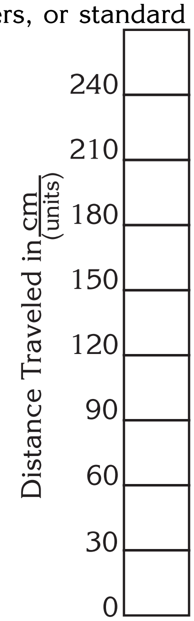
In order to help clarify our understanding that objects with smaller masses will travel farther than those with larger masses given an equal force, let's take our previous example and use a sphere with a lesser mass, three grams. The force is still 12, but the mass has been changed to three. Using algebraic reasoning for this science problem, we can determine the acceleration: 12 (force) = 3 (mass) X ? (acceleration).

The acceleration is obviously 4. The smaller mass resulted in a greater acceleration! (There are other factors, such as friction, which also need to be considered in this type of problem. However, in order to keep the basic understanding intact, this activity does not address these factors.)

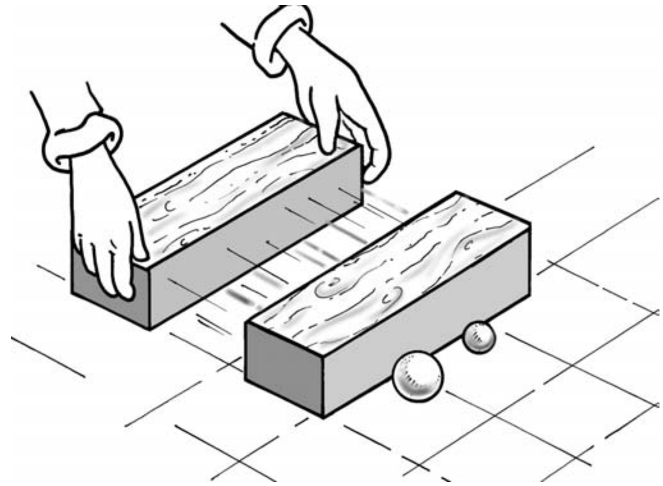
Students can apply these concepts to the varied balls used in sports. Softballs, baseballs, basketballs, soccer balls, etc. have different masses. Each ball is designed according to the goal of the sport and one could not be easily substituted for another. Some sports require the ball to roll a great distance, others require more of a bounce, while others need a ball which can withstand different amounts of force such as the swing of a bat, a golf club, or a swift kick.

Management

1. Provide two spheres that are of differing masses and sizes (volumes) for each group. High quality marbles such as: a steelie, a boulder, a shooter or medium marble, and a purie or small marble. Many of the lessor quality marbles have defects in their shape that can affect the test data. Golf balls and table tennis balls can also be used and are usually made with more accuracy in shape than an inexpensive marble. Be sure each group has spheres with a difference in mass of at least 10 grams.
2. Designate a sphere rolling area where the students can freely roll the spheres without obstructions. Instruct the students that no spheres will be shot through the air, that they are to roll the spheres, not flick them.
3. Each student will need copies of both student activity pages. When students display their graphs, only one student from each group needs to contribute a graph to the class display. One *Word Bank* page can be cut into fourths. Each student will need one-fourth.
4. The class will need to determine the type of unit of measurement — inches, centimeters, or standard units such as Unifix cubes — they will be using to measure the distance the spheres travel before you complete the labeling of the graphs. Once a unit of measurement has been chosen, label the left side of the graph using a range of units. For example, if you are measuring in centimeters, the vertical axis would be labeled as illustrated.



5. All groups can use the same *Roll Starter*. Use two blocks of wood (each approximately 2" x 4" x 5") to make the *Roll Starter*. The spheres will receive their push by aligning them against the front side of one of the blocks of wood. The students will then quickly slide the other block into the back of the first block. This will insure that both spheres received the same force.



6. Please note that throughout the activity when the term "size" is used, it is referring to volume. Young children understand that one sphere can be larger or smaller in volume than another, and they would, in most instances, refer to this as different sizes.

Procedure

1. Give each group of students a set of spheres, a balance, and recording pages. Give them some time to examine, roll, compare the mass, and discuss their spheres with their group. Distribute the *Word Bank*. Explain that they may want to use some of these vocabulary words to describe their observations on their student pages. Tell them to determine which sphere is the heavier and which is the lighter. (For older students you might provide a set of Unifix cubes or gram masses to quantify the mass of the spheres. For younger students it is sufficient to put each sphere in a pan of the balance and note the heavier side which moves downward.)
2. After a time of exploration, discuss what the students observed about their set of spheres. [The one with the larger mass rolled slower than the one with the smaller mass. They all rolled. They go round and round.] Discuss the shape of the spheres, the differences in the mass of the spheres, and the motion and direction in which they move. Ask the students if the amount of push or force they use to push the spheres makes any difference on the direction or distance they travel.
3. Tell the students they will be conducting an investigation with these spheres to determine how they move. Describe how each sphere will be lined up on a starting point on the floor. Explain how they will be giving the spheres a push and then they will measure and record the distance traveled. Help the class choose a testing area. Ask the students to mark a starting place with a piece of masking tape. Distribute the measuring tool they are to use to determine the distance each sphere travels.

4. Demonstrate the proper method of rolling a sphere along the testing surface. Show them the *Roll Starter* and how to use it (see *Management 5)*. Discuss how the *Roll Starter* helps to make the test fair as it helps make sure that the amount of push given to each sphere is the same. Discuss appropriate behavior (see *Management 2)*.
5. Invite a student to demonstrate the proper way to use the measuring tool to determine the distance a sphere travels on the testing surface.
6. Once the testing surface is ready, challenge the students to predict which of their spheres — the heavier one or the lighter one — will roll farther on the test surface. Ask them to also estimate the measurement of that distance. Instruct the students to record their estimations and predictions on their student page. (The students can also mark their predictions next to the testing surface using pieces of masking tape labeled with their names.)
7. Allow time for each group to test both spheres while the others watch. Direct each group to record the results on their group graph. Ask them to display the graph for the entire class to see the data collected.
8. Discuss the results.

Discussion

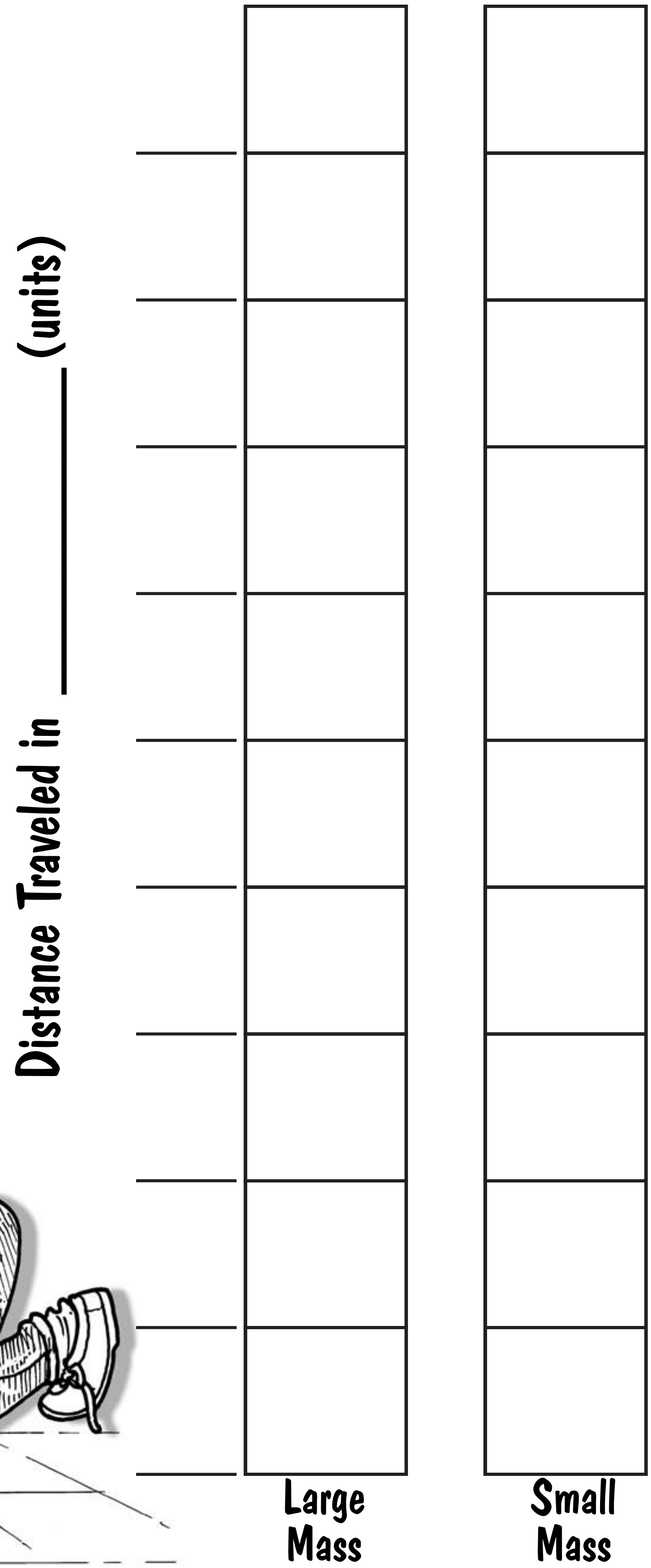
1. Did all the spheres travel in the same path? Describe the way most of the spheres traveled? Did they move in a straight line, a curve, or a zigzag?
2. Which sphere rolled farther? Describe the mass of this sphere compared to the sphere that didn't roll as far.
3. Was your prediction of which sphere would roll farther correct or incorrect?
4. Do you think the mass of a sphere makes a difference in the distance it will travel when given a push? Explain.
5. How close was your estimation of how far the sphere would travel?
6. Explain what you think causes a sphere to roll.
7. Name other objects that have the same shape as a sphere. If we tried to roll these objects, describe what you think the motion would look like. Explain why you think this.
8. Now that you know that spheres of different masses travel differently, what do you know about some of the spheres that are used in sports? What would happen if you used a softball ball to play soccer? ... a soccer ball to play golf?
9. What could you do to change the way the spheres traveled? [Push them harder. Put something in front of them to change their direction. Change the surface of the testing area. Put them on a ramp.]
10. Why do you think some of our spheres traveled farther than others? Did the amount of push or force you used to start the motion make any difference in the test results? Do you think it would? How could you test this to find out if it is true?
11. Do you think the size (volume) of a sphere makes a difference in the distance it will travel when given a push? How could you test this?

Extensions

1. Ask the students to bring in a variety of different spheres to test. Encourage them to bring in spheres made from different materials such as wood, rubber, plastic, foam, etc.
2. To help clarify the concept that mass is the determining factor in the distance the sphere will travel, and not size (volume), try to find a set of spheres that has one which is smaller in size but larger in mass compared to the second one that will be larger in size, but smaller in mass.

Spheres on a Roll

We discovered that ...



Spheres on a Roll

A description of our spheres ...

Sphere 1

Sphere 2

I predict ...
Sphere ______ will roll farther because,

How far do you think it will roll? ______
(units)

Spheres on a Roll Word Bank

balance	position
direction	push
distance	roll
farther	round
fast	shorter
grams	size
greater	slow
large	small
less	sphere
more	straight
motion	volume

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