ACTIVITY 24

Moving Masses*

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 3
Activity 24

SC.C.2.2.2
The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.C.2.2.3
The student knows that the more massive an object is, the less effect a given force has.

SC.C.2.2.4
The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.

SC.H.1.2.1
The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

SC.H.1.2.2
The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

SC.H.1.2.3
The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

SC.H.1.2.4
The student knows that to compare and contrast observations and results is an essential skill in science.

SC.H.3.2.2
The student knows that data are collected and interpreted in order to explain an event or concept.

*indicates Scientific Method Experiment

ACTIVITY ASSESSMENT OPPORTUNITIES

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. Ask, *Which accelerates faster from a stopped position if equal force is applied, a car or a truck? Why?* (A car is usually lighter than a truck and therefore accelerates faster when an equal force is applied.) Ask, *Which requires more force to stop its forward motion, a car or a truck? Why?* (A truck is usually heavier than a car and therefore must have more force applied to slow it down.)

2. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

ACTIVITY 24

Moving Masses

OBJECTIVES

In this activity, students learn that more massive objects require a greater force than do less massive objects for the same acceleration. They then use this information to predict how mass affects the rate at which two balls fall.

The students

- observe the relationship between force and acceleration
- observe the relationship between mass and acceleration
- compare their results with their hypotheses
- predict the falling rate of balls of different masses

SCHEDULE

About 40 minutes

VOCABULARY

acceleration
controlled variable
dependent variable
hypothesis
independent variable
Newton's second law of motion

MATERIALS

For each student

1	Activity Sheet 24, Parts A–D

For each team of four

1	bag, for spring scale
1	ball, steel
1	ball, wooden
1	book, hardcover*
1	spring scale

*provided by the teacher

PREPARATION

1. Make a copy of Activity Sheet 24, Parts A–D, for each student.
2. Place all the materials on the distribution table. Be certain that the spring scales are set to zero before students use them.
3. Each group will need a flat surface to roll the balls on, as well as a table off of which they can push the balls. Practice rolling the balls off the table beforehand to be certain the flat surface is smooth enough for students to observe the greater acceleration of the less massive ball.
4. If your classroom is not carpeted, you may want each group to use a folded bath towel or flat notebook to cushion balls that fall onto the floor.

BACKGROUND INFORMATION

In this activity, students observe behaviors that confirm ***Newton's second law of motion.*** This law states that a greater unbalanced external force causes a greater acceleration of an object in the direction of the force. A greater unbalanced external force is required to accelerate an object with more mass. If your students are comfortable with algebraic

expressions, $F = ma$ is a more complete description of this law, where F = force, m = mass, and a = acceleration.

Students use this law in interpreting the behavior of balls of different masses, and then apply this law in hypothesizing which ball will accelerate faster when an equal force is applied to balls of different masses.

Acceleration is the rate of change in the speed or direction of an object. Therefore, acceleration can mean speeding up, slowing down, or changing direction. In this activity, however, it is used in the context of change in speed only. This is because if an object is moving in a straight line, acceleration refers only to the rate at which its speed changes.

▼ Activity Sheet 24, Part A

Moving Masses

1. **Title**
   Sample answer: Mass and Moving Objects
2. **Statement of the Problem**
   Sample answer: How does mass affect moving objects?
3. **Background Information**
   Acceleration: Sample answer: Acceleration is the rate of change in the speed and direction of an object. It can mean that something is speeding up, or slowing down, or changing direction.

   Newton's second law of motion: Sample answer: Newton's second law of motion states that an object accelerates in the same direction as the net force on the object. It also states that more force is required to accelerate more massive objects. The law can be written as the formula, F = ma. F represents force, m represents mass, and a represents acceleration.
4. **Hypothesis**
   Answers will vary. Students may say that more force is required to accelerate more massive objects.
5. **Variables**
   Controlled Variables: Sample answer: amount of force applied to each ball, type of surface, type of book, type of scale
   Independent Variable: mass of balls
   Dependent Variable: rate of acceleration

▼ Activity Sheet 24, Part B

Moving Masses

6. **Materials**

1 bag for spring scale	1 steel ball	1 wooden ball	1 hardcover book	1 spring scale

7. **Procedure**
   Sample answer: First determine the mass of the balls in grams using the spring scale. Record the data. Then place both balls at the edge of a smooth, flat table. With a hardcover book, give the balls a quick push of the same strength toward the opposite edge of the table. Compare the acceleration of the balls. Record observations.

▼ **Activity Sheet 24, Part C**

Moving Masses

8. Data

Type of Ball	Mass of Ball	Acceleration of Ball
Wooden	23 g	fast
Steel	235 g	slow

Other observations:

Students may also note that some teams applied more force to both balls than did others. Regardless, the less massive ball should always roll faster whether the force applied to both balls was weak or strong.

9. Data Analysis

Sample answer: The data from the investigation showed that mass affects the acceleration of an object.

▼ **Activity Sheet 24, Part D**

Moving Masses

10. Conclusion

Sample answer: Given the same amount of force, less massive objects accelerate faster than do more massive objects.

Have you proved or disproved your hypothesis? Explain.

Answers will vary. Students should state whether or not their conclusion matched their hypothesis.

11. Recommendations

Students may suggest using a more controlled method to accelerate the balls. They may want to further explore how Newton's second law of motion applies to real-world situations.

12. Acknowledgements

Students may list team members who helped them complete the activity.

13. Bibliography

Students should list reference materials used to fill in the background information portion of this investigation.

Guiding the Activity

Additional Information

1. Briefly review the definition of *mass*. Remind students that mass is a measure of the amount of matter in an object. Mass is often confused with *weight*, which is a measure of the amount of gravity pulling on an object.

2. Give each student a copy of **Activity Sheet 24, Parts A–D.** Tell students to read the activity sheet. Answer any questions they may have about the steps.

   Explain that in this activity, students will examine the relationship between mass and the movement of objects. Allow students to review the materials on the distribution table. Ask, **What would be a good title for this activity? What scientific problem will you be exploring?** Have students write their answers in steps 1 and 2 on the activity sheet.

Guiding the Activity

	Additional Information
3 Give students time to research the terms listed in step 3 on the activity sheet. Students can use the Internet or reference books to conduct their research. After students have completed step 3, ask, **What is acceleration?**	*Acceleration means the rate of change in speed and direction. When an object is falling, its speed increases. Acceleration is a measure of the rate of increase (or decrease) in speed. If the speeds of two objects increase at the same rate, then the objects have the same acceleration. Be certain that your students understand acceleration before proceeding with the activity.*
4 Write the following terms on the board: **hypothesis** and *variables.* Use examples from this activity to clarify each term for students.	*A hypothesis is an educated guess about a scientific problem. In this activity, the scientific problem concerns moving objects and mass. A variable is a factor in an experiment, such as the mass of the balls or the surface over which they are rolled. There are different kinds of variables. During an experiment, a **controlled variable** does not change. An **independent variable** changes. A **dependent variable** changes in response to changes in the independent variable.*
Place students in groups of four. Have the groups review the scientific problem they wrote on their activity sheet. Ask them to form a hypothesis based on the scientific problem. Students should write their hypotheses in step 4 on the activity sheet.	*Review and approve each team's hypothesis before proceeding.*
Make sure students understand the concept of variables before proceeding. Ask, **What variables stay the same in this experiment?**	*Guide students to see that the type of surface, the amount of force applied to each ball, the type of scale used to weigh the balls, and the type of book used to push the balls are all the same.*
What is the independent variable in this experiment?	*Be certain students understand that the mass of the balls is the variable that changes in this experiment.*

Guiding the Activity

What is the dependent variable?

Help students to understand that the rate of acceleration is the variable that will change in response to changes in the independent variable.

Tell students to complete step 5 on the activity sheet.

5 The materials should already be in place at a central distribution station. Have each group select the materials they will use to test their hypothesis.

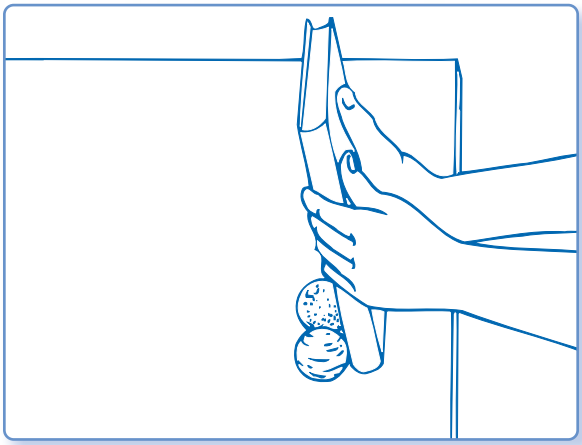
Each team of four will need one bag for the spring scale, one steel ball, one wooden ball, one hardcover book, and one spring scale.

6 Tell students they will need to develop a step-by-step procedure to test their hypothesis. First, walk them through each step. Tell them that they must first determine the mass of the balls in grams using the spring scale.

Next, they should place both balls at the edge of a smooth, flat table. With a hardcover book, they should give the balls a quick push of the same strength toward the opposite edge of the table. They will need to carefully compare the acceleration of the balls and record their data and observations on Part C on the activity sheet.

Have students write their procedure on the activity sheet and then carry out the procedure. Make sure they enter their data and observations on their activity sheets as they conduct their experiments.

Watch as students push both balls with a book (see Figure 24–1). This activity works well on a smooth surface. If the surface produces too much friction, it will slow the balls and diminish the effect that students are supposed to observe.



▲ ***Figure 24-1.*** *Accelerating the balls.*

If students do not observe the greater acceleration of the less massive ball, point it out.

It is also important for students to push the balls and pull the book away quickly. If they move the book forward with the balls, they will not achieve the results intended.

Guiding the Activity

	Additional Information
7 After teams have pushed the balls and observed the results, ask, **What is the relationship between force and acceleration in this step? between acceleration and mass?**	*The stronger the force, the greater the acceleration (the harder the push, the faster the balls rolls—direct relationship).*
Newton's second law of motion explains the phenomenon students have observed. It states: An object acted on by a force will accelerate in the direction of the force. Further, the acceleration of an object is directly proportional to the external force acting on it and inversely proportional to the object's mass.	*Newton's second law states that the force on an object is the product of its mass and its acceleration—force* (F) = *mass* (m) × *acceleration* (a), *or* F = ma. *Thus, acceleration* (a) = *force* (F) ÷ *mass* (m), *or* a = F/m. *In this example—the book striking two balls of different masses—the force* (F) *applied by the book is the same for each ball. Because* a = F/m, *and the force* (F) *is the same for each ball, for a greater mass* (m) *the value for acceleration* (a) *will be less. So, for the ball with the greater mass, acceleration is less and it rolls slower. For the ball with the lesser mass, acceleration is greater and it rolls faster.*
8 Allow teams to complete their activity sheets. Then extend the activity by asking them to predict which ball will reach the ground first if both balls are dropped simultaneously.	*Some students will predict that the more massive ball will reach the ground first because it is heavier. Other students will predict that the less massive ball will reach the ground first because it accelerates more quickly.* *Note: If your classroom is not carpeted, you may want to use some sort of cushion, such as a folded towel, as a landing pad for the balls.*
9 Have student practice pushing both balls off the table to be certain that both balls are leaving the table at the same time. Then have a student at ground level in each team confirm that both balls hit the ground at the same time.	***Safety Note:*** *Make sure the students observing the balls at ground level are wearing safety goggles.*
After students complete the activity, ask, **How can you explain your observations using Newton's second law of motion?** Let students brainstorm their answer as a team.	*The two balls hit the ground at the same time and were dropped from the same height. Thus, they accelerated at the same rate.* *A greater force is required to accelerate the ball with more mass at the same rate as the ball with less mass. Here is how this is explained in terms of Newton's second law:*

Guiding the Activity

Additional Information

Because a = F/m, *the acceleration* (a) *is the same for each ball and the mass* (m) *of each ball is different, the force* (F) *acting on each ball must be different. For the ball with greater mass* (m), *the force* (F) *must be greater for acceleration to be equal to that of the less massive ball.*

Remind students that, based on previous experiments, they know that the ball with more mass will experience a greater gravitational force because the magnitude of the gravitational force is directly proportional to the mass of the ball.

Reinforcement

Collect the spring scales and the bags. Then give each team one table tennis ball. Ask the teams to predict which of the three balls will accelerate most quickly when the balls are hit with the book. Ask them to predict which of the three balls will reach the ground first. Then let the teams do the experiments and report their results.

Science Journals

Have students place their completed activity sheets in their science journals.

Cleanup

Return the spring scales, the bags, and the wooden and steel balls to the kit.

Connections

Science Challenge

- Ask students what they think happens when two forces act on an object in different directions. Discuss students' ideas. Then have pairs or teams of students do the following activity to test their ideas. On a large sheet of paper, draw a wide, straight river with two docks on opposite banks. Position a pencil point representing a boat at one dock, and "row the boat" (move the point) across the river to the opposite dock. What path does the boat follow? (a straight line) Now tape two sheets of paper together to form a long strip, trim it to the width of the river, and put it over the river. Repeat the boat's travel across the river, but this time gently pull the paper strip to represent water flowing in the river. Where does the boat land this time? (downriver from the opposite dock) Ask students to explain this result. (The forward motion of the boat caused by rowing straight across the river and the sideways motion of the current combine to move the boat diagonally across the river.)

- Ask students to think of other examples in which two or more forces combine to influence an object's motion. For each example, have students identify whether acceleration occurs (i.e., whether there is a change in the object's speed and/or direction of motion). Ask students to describe the effect on the object. What happens to an object if two equal forces push or pull on it in opposite directions? (No acceleration occurs, and the object remains stationary or maintains it original motion.)

Science Extension

- Students observed that the wooden ball and the steel ball hit the ground at the same time even though the weight of the steel ball is about ten times the weight of the wooden ball. From this observation, what can they infer about the gravitational forces attracting the balls? (The gravitational force acting on the steel ball is about ten times greater than the force acting on the wooden ball.) Provide balls of different weights, and have students weigh each ball. Then have them drop the balls in pairs to determine whether they hit the ground at the same time. Ask students to describe the gravitational force acting on each ball compared with the force acting on the wooden ball.

- Show a short film or video, and stop at various points and ask students to identify examples of acceleration that they see. Make sure students understand that a change either in speed or in direction—not necessarily both at the same time—is acceleration.

Science and Language Arts

- Explain that scientists use the term *acceleration* to refer to either an increase or a decrease in an object's speed. Ask, What word is commonly used by people to describe a decrease in speed? (deceleration) Have students suggest other terms that have different meanings in science and in common usage.

- Ask students to think about what the world would be like if Earth's gravitational force attracted all objects with equal force, regardless of their mass—if, for example, a car were attracted to Earth with the same amount of force as a person is normally attracted, or vice versa. Suggest that students write short stories to describe such a world. Give volunteers an opportunity to read their stories to the rest of the class. Students also may enjoy working in groups to create and act out skits based on their stories.