GRADES 3–5

TIME
One–Two class periods
(40-50 minutes)

WEATHER—When Hail Attacks!

Science

CHILDREN'S MUSEUM INDIANAPOLIS®

WEATHER–WHEN HAIL ATTACKS!

The Children's Museum's lessons are designed to weave classroom experiences and museum education together. All lessons are interdisciplinary and can be used as individual classroom experiences or in combination to create a cohesive unit. Lessons are optimized when used in connection with museum field trips.

This lesson is divided into 2 parts that are intended to be done over 2 days of instruction. Part 1 can stand alone as a lesson without Part 2, but Part 2 must be used in tandem with Part 1.

Tornados, strong lightning, high winds, and flooding are all common products of a severe thunderstorm. **Instability** in the atmosphere accompanied by air masses of warm wet air and cool dry air can be a catalyst for these severe storms. Hail can also accompany severe thunderstorms. Scientists study the effects of severe weather on materials and structures to build safer homes and buildings. This two-part lesson is designed to test the effect of hail size and apply experiment results to an engineering design challenge.

INDIANA ACADEMIC STANDARDS

Science: 3.ESS.1, 3.ESS.2, 4.PS.2, 4.PS.5, 5.PS.1, 5.PS.2, 5.PS.3, 5.PS.4, 5.PS.5, 3-5.E.1, 3-5.E.2, 3-5.E.3

OBJECTIVES

Students will:

- Understand how thunderstorms create hail
- Identify how hail can change in size due to elements in the atmosphere
- Discover how changes in the atmosphere can create extreme weather
- Describe how researchers monitor hail
- Brainstorm how an engineer's design for hail protection might differ between structures, cars, or equipment

FOCUS QUESTIONS

- How are thunderstorms created?
- How is hail formed?
- What elements in the atmosphere create extreme hail storms?
- What instrument(s) help scientist monitor weather?
- How do engineers design hail-proof equipment?

MATERIALS

(Per student or group)

- 8" x 8" or larger metal baking pan
- Any granular/powdered baking medium (flour, corn starch, corn meal, sugar, etc.) – enough to cover the bottom of the pan by at least 2 inches.
- Balls/rocks of various masses and sizes
- Gram/kitchen scale
- Measuring tape
- Post-it Notes
- Rulers (for measuring in cm.)

Exploring Hail Size–Part 1

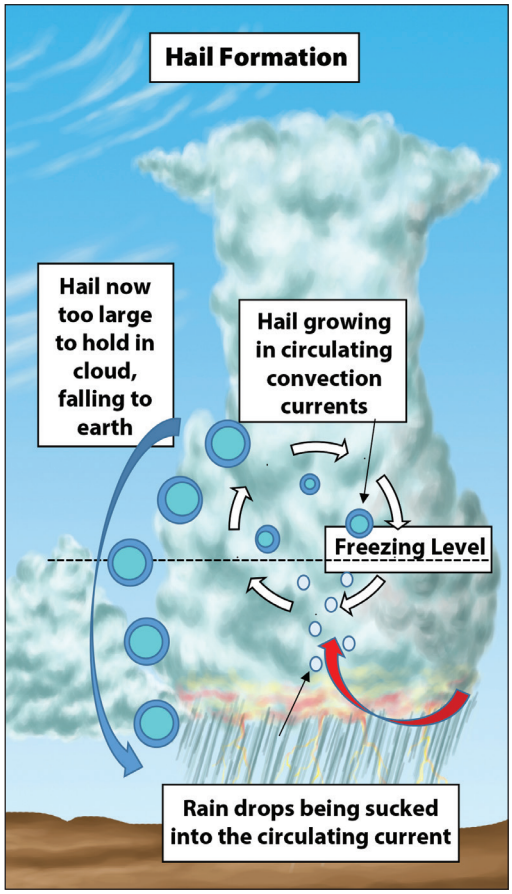
Read all instructions before beginning the lab activity. Remember to wear safety equipment at all times.

PROCEDURES

Part 1: Teacher Steps
Exploring Hail Size

1. Explain that hail comes from a specific type of cloud called a **cumulonimbus cloud**. The cumulonimbus cloud is the cloud that is associated with thunderstorms and lots of rain. These types of clouds form in the lowest part of the atmosphere, closest to earth, so evaporation and warm air rising help create them.
2. Using the sidebar diagram, illustrate the movement of water droplets within cumulonimbus clouds. Water droplets can be blown high into the cloud where the temperature is lower, which causes the water droplets to freeze and become ice masses. As the ice masses fall, they catch more water droplets and slush forms around the ice mass. The wind blows the ice mass high into the cloud once again and the newly formed slush freezes, increasing the mass. As the ice masses fall and are blown back up into the highest, and coldest, parts of the cloud over and over, the hail continues to grow in size. This is similar to adding rubber bands to a rubber band ball. The hail falls to earth when it becomes too heavy to be blown upward into the cloud.
3. Explain to the student(s) that meteorologists typically use what is called a **hail pad** to monitor and measure hail stones from storms. These pads are made of styrofoam, and they can hold the imprint of a hail stone after impact for measurement and analysis. Using kitchen items, student(s) are going to create a way to collect data similar to that of a hail pad.

DIAGRAM A



4. Explain to student(s) that they're going to be doing a hail damage test to model the effects of hail on common surfaces.
5. For older students, review Diagram A and ask the student(s) why they think each group's ball has a different weight, and why everyone is dropping the ball from the same height. This is because the experiment is testing the effect of mass on the force of a moving ball. All tests are occurring from the same height, in order to test only one variable at a time.
6. Demonstrate the test procedures described below. Ask the student(s) why they think they're repeating the procedure five times (to get a range of data in case any single test was flawed in some way).
7. Once all of the groups have finished gathering their data, have them report to the class. What did their ball / rock weigh? What size indentations did it leave? What can they infer from this information? (Objects with more mass exert more force even if they are dropped from the same height and are moving at the same speed).
8. Explain that hailstones are formed in the atmosphere. Depending on how long the hail stay inside clouds before falling, they can be as small as a few millimeters to as large as a few inches in diameter. Additionally, collisions between the hail stones can cause them to stick together forming an even larger ball of ice. The largest hailstone ever officially recorded was almost 8 inches across!
9. Using what they've just learned, ask the student(s) how the size of hail might affect its force and thus its ability to cause damage (larger hail causes more damage). Explain that hailstones can also have different speeds based on how far they fall or how fast the wind is blowing, and have them speculate how that might affect hail's force.

Exploring Hail Size–Part 1

Read all instructions before beginning the lab activity. Remember to wear safety equipment at all times.

PROCEDURES

Part 1: Student Steps
Exploring Hail Size

These activities can be done as group work in a classroom or as an independent investigation at home.

1. Before starting the experiment, using the measuring tape and a chair or stepstool measure 8 feet up on a wall, then mark the measurement with a Post-it Note. (Note: Adults should assist with this process)
2. Choose a rock or ball that will represent the piece of hail. Weigh the ball/rock and record its mass in a data table or in a science journal.
3. Fill the pan with at least 2 inches of flour (or alternative) tap the bottom of the pan on the table/countertop to level the surface over the area of the pan.
4. For each drop test, complete the following steps:
   a. Place the hail pan on the floor under under the mark made at 8-foot using the Post-it Note.
   b. Drop, don't throw, the ball/rock straight down into the hail pan from 8 feet up.
   c. Measure the diameter (in cm) of the dent it leaves in the hail pan medium. If the dent isn't circular, measure it at its widest point.
5. Record the width of the dent in a data table or in science journal.
6. Record data from 5 test drops in the data table provided.

HAIL DATA

Trial	Width of dents (in centimeters)
1	
2	
3	
4	
5	
Average:	

To take average, add the numbers in column 2 together and divide that sum by 5.

TEACHER TIPS

When students are working in groups to conduct science experiments, providing them a job is a great way to ensue students are on task. For this experiment, the following jobs can be assigned to students.

1. Break the students into groups of 5. Assign each student to a job for the experiment.
   a. **Dropper** – they will drop the balls onto the pan, representing the hail pad.
   b. **Chaser** – they will retrieve the dropped balls/rocks and return them to the dropper.
   c. **Measurer** – they will measure the diameter of the indentations made by the balls/rocks, representing the hail.
   d. **Recorder** – they will write down the diameter of the indentations in the table titled: Hail Data.
   e. **Leveler** – they will lightly shake the pan and tap it gently on the floor to re-level the pan's medium for each new trial to provide a fresh surface to test on.
2. If groups have more than 5 students they can rotate through jobs.

Engineering Hail Protection–Part 2

This lesson is divided into 2 parts that are intended to be done over 2 days of instruction. Part 1 can stand alone as a lesson without Part 2, but Part 2 must be used in tandem with Part 1.

Read all instructions before beginning the lab activity. Remember to wear safety equipment at all times.

PROCEDURES

Part 2: Teacher Steps
Engineering Hail Protection

1. Review what students learned about the size of hail stones. Ask the student(s) how the size of hail might affect its force and thus its ability to cause damage (larger hail causes more damage). Explain that hailstones can also have different speeds based on how far they fell or how fast the wind is blowing, and have them speculate how that might affect hail's force.
2. Share with the students that now that they know a bit about hail and how it can damage structures, cars, and even living things, it's time to work on solutions.
3. Explain to student(s) that it's time to switch from the scientific process to the engineering design process. Do they know how engineers work? (in short, design-build-test-redesign, and so on.) Using the provided building materials, students will create a shield that can absorb the force of their hailstone and protect their hail pan.

CITIZEN SCIENCE WITH CoCoRaHS

Pronounced "Coco-Rahz", The Community Collaborative Rain, Hail & Snow Network is an organization that encourages citizen science by utilizing classrooms and families in real-time data reporting. Meaningful connections outside of the classroom walls encourages life-long learning and scientific inquiry. Visit: https://www.cocorahs.org to get your students involved

Part 2 - Student Steps:
Engineering Hail Protection

1. Provide students with 5-10 minutes to discuss a design and sketch the design on a piece of paper or in a science notebook.
2. Give students 10-15 minutes to design and build their shields, then review the test procedure from Part 1 of the lesson. For this test, students will complete 3 drops per trial. Following the trial, students should record how well the shield worked to protect the hail pan from damage. Note: If students were assigned jobs (see sidebar: Teacher Tips from Part 1), have them continue to use their assigned jobs.
3. If their first trial does not fully protect the pan from damage, they must modify their design, reset the pan, and try again. If their first or second trial is fully protective, they must think of a way to improve it. Can it be made lighter, more easily transportable, or more visually attractive?
4. Once the student(s) have run 3 trials of their shields, have them share what they learned. What did and did not work? Which materials made for a good barrier and which offered poor protection? Students can also share their results in a writing assignment or engineering report.
5. Discuss how this exact problem might come up in the real world. What types of jobs might be worried about hail damage? What might have happened to buildings, cars, etc. in the past that might be different from what could happen now?

Make a Real Hail Pad

To make a personal hail pad, you will need:

- 12″x12″ piece of styrofoam
- 18″x18″ square of aluminum foil
- Scotch or packing tape

1. Place a sheet of foil on a smooth, soft surface such as a t-shirt or cloth. Make sure that the shiny side is face up! (The dull side will be on the outside face of the pad.)
2. Place the styrofoam square at the center of the aluminum foil.
3. Fold the sides up making sharp creases and carefully begin folding the corners, just like wrapping a present.
4. Tape the outside edges of your foil around the styrofoam square.
5. Put the pad outside to record the hail from your next storm. It can be secured so it doesn't blow away by cutting two "L" shaped wires from a metal coat hanger and secure the pad to the ground like tent stakes (if needed).

VOCABULARY

- **Cumulonimbus Clouds**
- **Instability**
- **Hail Pad**

VARIATIONS OF HAIL DEPENDING ON LOCATION

"Certain parts of the world receive more hail than others. The approach of the summer monsoon season in India brings severe thunderstorms, often with tornadoes and hail. A particularly deadly hail storm in Moradabad, India, in 1888 killed more than 250 people. China also experiences frequent hail storms, as do parts of the Midwestern United States. In fact, the Great Plains region of the United States and Canada is called Hail Alley." *(National Geographic)*

Pea sized hail producing clouds near Kinderhook, Michigan March 20, 2003

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