Meteoroids & Craters

This activity consists of a few simple experiments in which students will create a model of crater formation to determine the effect of (1) size of meteoroid, (2) speed of meteoroid, and (3) angle of approach. In the first two experiments, the outcome is fairly easy for students to predict. The third experiment is a bit more thought-provoking and surprising.

Objectives

For students who are already familiar with the idea of controlling variables in experiments, this activity will provide a good exercise in addition to providing insights into crater formation. For students in grades 4 and above, identifying variables and performing the controlled experiments should be a reasonable challenge. For younger ages, the activity can take on more of an exploratory approach in which ideas form as the model meteoroid impacts are observed.

After this activity, students will be able to:

1. Identify factors that might affect crater formation.
2. Predict the outcome of experiments.
3. Perform simple experiments concerning meteoroid impacts and crater formation.
4. Record their observations.

Materials

For the Class

- 1 projector and screen
- 1 or more brooms or whisk brooms to clean up spills
- 1 pair of scissors or a paper cutter (to cut the centimeter rulers off the student data sheets)
- one container instant chocolate milk powder. (Note: Real cocoa has also been used, but it tends to clump and to over-darken the flour too quickly.)
- three or four 5-pound packages of white flour
- Optional: projectable images of Earth's Moon and a close-up view of a large crater

For Each Student

- 1 pencil
- 1 "Crater Experiments" activity sheet (master on page 7)

For Each Team of 4 Students

- 1 shallow basin (to be filled with about 3 to 5 inches of flour)

  Examples: a dishpan, a heavy aluminum roasting pan, or cardboard box. To be sure to have enough, you may want to ask a student from each group to bring in a dishpan from home for the day of the activity. They don't all have to be the same size.
- 1 cup or small plastic container (to be filled about one-third full with powdered instant chocolate milk mix)
- an old newspaper
- three rocks: small, medium, and large with diameters about: .5 cm ($^1/4$ inch), 2 cm ($^3/4$ inch) and 4 cm (about $1^1/2$ inches)
- 1 spoon (plastic or metal)

Before Class

1. Before the day of the activity, collect and sort the rocks needed for all the groups.
2. Make one copy of the "Crater Experiments" data sheet for each student (master on page 7). With scissors or a paper cutter, cut the centimeter rulers from the bottom of the data sheets.
3. Assemble sets of materials for the teams: newspaper, a dishpan filled with flour 3 to 5 inches deep, a cup about one-third full of instant chocolate milk mix, and three different-sized rocks. Have data sheets, paper rulers, and pencils handy, but separate from the other materials. Keep one set of all the materials handy near the place where you will demonstrate the activity.
4. Try the cratering activity yourself—decide whether your students will do the activity indoors or outdoors.
6. Optional: Set up the projector with Moon and crater images.

In Class

Part 1: Introducing Craters

1. The name of Earth's Moon is Luna.

   What do you imagine the surface of our Moon is like? What would it feel like to be walking on Luna? What would you see around you?

   Optional: Show image of the Moon. This is how our Moon would look if viewed through a small telescope.

   What do you see on the Moon's surface? [Light areas, dark areas, craters etc.]

   If somebody mentions craters, have them point out an example of one for the class. If craters are not mentioned, point out a large one and identify it as a crater. Explain that craters are big "dents" or holes in the Moon's surface.

2. A meteoroid is a rock in space—it can be any size all the way from microscopic to many meters across. A meteor is the same rock falling through the Earth's atmosphere, creating a streak of light (sometimes also called a "shooting star"). Fragments of meteors that survive the fiery trip through the atmosphere and land on the Earth's surface are called meteorites.

   What causes craters on the Moon? [Meteors, asteroids, big rocks, comets, etc.]

   Are craters on the Earth?

   If anybody has visited a crater site, have them share their experience with the class.

   The Earth has many craters. Some were caused by volcanoes. Others, called impact craters, were made by meteorites.

   Why do we see very few impact craters on the Earth? (The Earth has rain and wind which erode away the evidence of most craters.)

   Earth's atmosphere prevents small meteors from reaching the surface, because when a meteor falls towards a planet with an atmosphere, it "rubs" against the air. Rub your hands together quickly for several seconds to feel the heat of friction. If you could rub fast enough you would create enough friction to light a fire. In a similar way, the flash of light you see from a "shooting star" or meteor is a white-hot glow produced by the heat of friction between the meteor and the air. Because the Moon has no air to rub against, meteors do not burn up before hitting the Moon's surface. This is one reason why the Moon has lots of craters.

Part 2: Making Craters

1. Let's investigate what happens when a meteoroid hits a solid surface like that of the Moon. You will use a pan of flour and three different size rocks to investigate meteor craters. The flour will represent the surface of the Moon and the rocks will be the "meteoroids."
2. Here's what to do.

   Demonstrate for the students:

- Place an old newspaper and a pan of flour on the floor near your feet.
- Sprinkle a light coating of instant chocolate milk mix on the surface of the flour to create a contrast that will help make changes more visible.
- Hold out a medium-sized rock at about shoulder level. Don't actually drop the rock. Drop, DO NOT THROW, the rock into the flour.
- After you drop the "meteoroid," observe what happens to the flour.

3. Ask "What do you think will happen?" (Have several students make predictions.)
4. You will work in groups, and take turns dropping the rocks into the flour. It's not necessary to smooth the flour and apply chocolate milk mix after each try.

   Distribute the materials to the teams and let them freely explore the materials and practice making craters for about five minutes.

   What did you find out? What features did your craters have?

   You may want to have a few volunteers draw what they saw on the chalkboard. As students describe the various features, write some terms on the board. [The impression left on the surface is called a **crater basin**. *Students may have noticed a* **rim** *around the edge of the basin and streaks or* **rays** *that radiated outward from the crater.]*

Part 3: Meteor Experiments

1. There are craters of many different sizes on the Moon.

   What might affect how big craters will be? [Meteoroid size or weight, speed at impact, direction, or type of surface material.]

2. Our research teams will now conduct experiments to find out how two of those factors affect the size of the craters: the size of the meteoroid and the speed of impact.

Hold up a data sheet and explain the two experiments:

Experiment #1: Size of Rock

Make three craters with each of the three rocks (a total of nine craters for Experiment #1). Drop each rock from the same height. Measure the diameter of the crater, using a paper centimeter ruler. Record the crater diameters on the data sheet after each drop. Repeat three times for each rock.

Why will it be important to drop all the rocks from the same height? [Then, if the crater size varies, they'll know it's because of the size of the rock.]

You can use one team member's shoulder height as a standard for every trial. Remove the rock from the flour very carefully, so you don't disturb the crater.

After each trial, jiggle the container back and forth a few times to level the flour and sprinkle more chocolate milk powder on top if the surface needs it.

If the flour becomes very dark from cocoa, or if a team has used up all its chocolate milk powder, sprinkle flour on the surface instead of the powder to create a contrast.

You may want to have the students calculate averages, although the results may be evident without it.

Experiment #2: Speed of Impact

This time, use only one rock to make all the craters, but drop the rock from different heights: knee-high, shoulder-high, and as high as they can reach when standing on the floor. A rock gains speed as it falls, so the farther it falls, the faster it will be going when it hits the flour. Make three craters from each of the three heights. (A total of nine craters for Experiment #2.) Record the crater diameters on the data sheet after each drop.

Why should we use the same rock when we are experimenting with different speeds of "meteors? [If we used different rocks and different heights, we won't know which made the differences in crater sizes.]

Knee-high, shoulder-high, and as high as you can reach may vary for different students.

How can you keep the height standard on all three tries? [Take turns dropping the rock, but use one student's shoulder height for all tries.]

Hand out the data sheets and paper rulers and have them begin. Circulate during the experiment, checking to be sure students are working safely and cooperatively in their teams.

If a team finishes early, suggest that they extend their investigations in Experiment #2 by, for example, carefully standing on a chair to drop the rock. (Older students may want to extend their investigation by observing or measuring crater depths created by various sizes or speeds of "meteoroids." The long "rays" that radiate from their "craters" could also be measured.)

As teams finish, have them return their equipment to the materials area and clean up. Have them keep their data sheets for the discussion.

3. Analyze your experiment by looking at your data for Experiment #1, comparing meteor sizes.

Describe what you observed and recorded. Does the size of the meteoroid have anything to do with the size of the crater? [Your students' experimental data is likely to vary, but many students will find that crater size increases with the size of the meteoroid.]

What can you conclude from Experiment #2, about meteors that have struck with different speeds? [Again, student data will vary, but many students will conclude that the faster the meteor, the bigger the crater.]

Real craters caused by actual meteor impacts are about 20 times the diameter of the meteor itself.

Going Further

1. Angle of Impact

Ask the students to predict the appearance of a crater if the meteoroid strikes the ground at an angle. (Most will assume that the shape of the crater will be different—not round.) Have the students conduct experiments in which they throw identical sized pebble at about the same speed, but at different angles. Instead of recording the diameter of the crater, record the shape of the crater.

Is the shape of the crater different? How would you expect the shape of the crater to change as the angle of impact is increased?

The results of this test are often surprising. One normally would expect the crater to have an oblong shape on extremely wide angle impacts. In fact, all craters that we have seen on the Moon or on Earth are pretty much circular. The reason is that on impact, an explosion occurs and the forces associated with an explosion are always spherically symmetrical. If your students examine images of many craters, they may notice that they all appear round. No matter the initial shape of the meteor (or the angle of its impact) the resulting explosion will always form a round crater.

Optional

Show the image of Earth's Moon again. Ask volunteers to point out some of the features of craters on the Moon that they recognize from their experiments. Show the close-up of a Moon crater and ask for more observations and comments.

2. Craters in Liquids

In close-up views of some large craters students may notice the central peaks. Modern scientists have been able to simulate actual meteor impacts with rocks fired from powerful guns (at 30,000 mph). At such speeds the meteor does not stop moving at the moment of impact. Friction rapidly heats the meteor and a tremendous explosion occurs. (Imagine quickly trying to change all the energy of a room-sized meteor traveling at 30,000 mph into heat!) If the meteor is large and fast enough, the ground liquefies, forming a crater with a rim around it. In large impacts the rim collapses, and the liquefied material rushing back into the center of the crater forms a mountain in the middle. Debris thrown out by the explosion forms rays that may extend for hundreds of miles. On Earth, small pieces of a meteor are sometimes found at the impact crater, confirming that the crater was caused by a meteor impact.

Your class can observe craters forming in liquids as follows:

For each group of four to six students, you'll need a cup of water, a medicine dropper (optional), and 1 blank sheet of paper. Pour a cup of water into a pie pan. If you are using medicine droppers, hold the dropper about a foot over the pan and allow a drop of water to fall into the pan. Or, dip a finger into the water so that a drop hangs from it, and shake the drop loose so it falls into the water. (Although the drop of water is a little bigger with the dropper, the fingertip method works fine.)

Encourage all members of the team to observe what happens from the side and from just above the surface of the water. Have the students take turns releasing drops and observing what happens. Each team should discuss their results and draw what they see on their papers. Here are some possible observations:

- As soon as the drop hits, it goes below the surface of the water, making sort of a "crater."
- Ripples come from the center, hit the walls of the pan, and bounce back and forth.
- A mound of water forms in the center of the crater, right after the drop is dropped. It may seem as if the drop "bounces" back after it hits the water.

What crater features can you see that you have not seen in the experiment with solids? [Concentric circles, ripples, and central peaks.]

Very large meteors that have struck the Moon move so fast that they melt the rocks. In these cases, even though the surface may have been solid before the impact of the meteor, we can sometimes see the central peak caused when the Moon's surface turned to molten rock for a few minutes, then solidified before the peak had a chance to become level again.

3. Making a Model of a Crater

As long as you have all that flour, why not use it to make sculptures of craters?

Show your students pictures of craters from various places in the solar system. Give each student a square of posterboard or cardboard. Mix flour, salt, and water into a thick paste and have your students use the paste to form craters on their boards. Set the finished craters aside to dry overnight.

Most craters in the solar system are various shades of grey in color, so painting of the craters may not be particularly exciting. However, Jupiter's moon Io has volcanic craters that have striking colors: orange, red, black, yellow. You can discuss with your class the difference between impact craters and volcanic craters and have your students form model volcanic craters such as those on Io which they can then paint in bright colors.

Crater Experiments

Experiment 1: Size of Meteoroid

What can you conclude?

Record the Crater Diameters for:

	Small	Medium	Large
1			
2			
3			
Average			

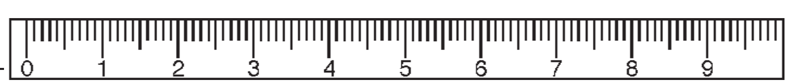
Experiment 2: Size of Meteoroid

What can you conclude?

Record the Crater Diameters for:

	Small	Medium	Large
1			
2			
3			
Average			

Centimeters:



Your Name: ______________________