

# Asteroid Impact Lab Experiment

## Objectives

- Students will identify former impact sites from asteroids or meteors on the Earth from print media, the Internet, etc.
- Students will identify impact sites on other celestial bodies including the moon, Venus, Mars, Rhea, Iapetus, Enceladus, Tehtys, Dione, Mimas, Hyperion, Callisto, Ganymede, Io, etc.
- Students will reproduce impacts in a simulation and measure and graph the effects.
- Students will write a reflective essay on this activity detailing experiences and insights into impacts and force.

## Suggested Grade Level

9<sup>th</sup> to 12<sup>th</sup>

## Subject areas

Integrated Science

Physics

Astronomy

Mathematics

Language Arts

## Timeline

One to two class periods

## National Science Content Standards

### Science as Inquiry

#### NS.9-12.1

**As a result of activities in grades 9-12, all students should develop**

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

### Physical Science

#### NS.9-12.2

**As a result of their activities in grades 9-12, all students should develop an understanding of**

- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

## **Earth and Space Standards**

### **NS.9-12.4**

**As a result of their activities in grades 9-12, all students should develop an understanding of**

- Energy in the Earth system
- Geochemical cycles
- Origin and evolution of the Earth system
- Origin and evolution of the universe

## **National Math Content Standards**

### **NM-NUM.9-12.1**

**Understand numbers, ways of representing numbers, relationships among numbers, and number systems**

- Develop a deeper understanding of very large and very small numbers and various representations of them
- Compare and contrast the properties of numbers and number systems, including the rational and real numbers, and understand complex numbers as solutions to quadratic equations that do not have real solutions
- Understand vectors and matrices as systems that have some of the properties of the real-number system
- Use number-theory arguments to justify relationships involving whole numbers

## **NM-ALG.9-12.2**

### **Represent and analyze mathematical situations and structures using algebraic symbols**

- Understand the meaning of equivalent forms of expressions, equations, inequalities, and relations
- Write equivalent forms of equations, inequalities, and systems of equations and solve them with fluency -- mentally or with paper and pencil in simple cases and using technology in all cases
- Use symbolic algebra to represent and explain mathematical relationships
- Use a variety of symbolic representations, including recursive and parametric equations, for functions and relations
- Judge the meaning, utility, and reasonableness of the results of symbol manipulations, including those carried out by technology

## **NM-GEO.9-12.2**

### **Specify locations and describe spatial relationships using coordinate geometry and other representational systems**

- Use Cartesian coordinates and other coordinate systems, such as navigational, polar, or spherical systems, to analyze geometric situations
- Investigate conjectures and solve problems involving two- and three-dimensional objects represented with Cartesian coordinates

## **National Language Arts Content Standards**

### **NL-ENG.K-12.1 Reading for Perspective**

Students read a wide range of print and nonprint texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.

### **NL-ENG.K-12.7 Evaluating Data**

Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

### **NL-ENG.K-12.12 Applying Language Skills**

Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

## **Background**

This lesson is appropriate for students studying science, specifically physics and/or astronomy. The students should have prior knowledge of astronomy and the forces of motion. Newtonian Laws would be a beneficial keystone to help the students bridge the gap between the observable phenomena in their daily lives to the abstract concepts of celestial motions. The students should have had some experience with inquiry-based learning and using simulations to demonstrate real-world concepts. Additionally, students should have sound laboratory practices including both safety and care and use of equipment. The students need to graph results using the Cartesian coordinate system, analyze their results, and write a reflective essay on their experience.

## Materials

Pencil, pen, note/binder paper, graphing paper, (optional: colored pencils or markers for graphs), shallow box ~ two by two feet and four inches deep, ten pounds of flour, dry powdered tempera paint, meter stick, stopwatch, metric ruler, spheres of varying density and size, i.e. marbles, golf balls, bearings, ping-pong balls, etc. scale/balance, calipers

## Lesson

1. Have students read and review articles on object impacts, specifically Earth impacts from comets and meteors.
2. Have the students view and analyze imagery on impacts using hard photos, Internet sources, and direct observations of the moon at night.
3. Have students construct data tables indicating the size of existing impact crater sites and the theorized size and speed of the impacting object.
4. Have students simulate impacts with the “Creating Craters” activity below. Repeat the process a sufficient number of times and record their data.
5. Students compare their simulation model data with the real-world data collected previously and extrapolate the size of the potential impact crater from the Apophis asteroid.
6. Have students make a critical analysis of the above data and write a reflective essay on the potential outcome from an Apophis asteroid strike.

## Extensions

Students can expound and enrich their experience in a number of ways. Start by repeating the Creating Crater activity using impact material of varying shapes and alter the trajectory of the impact. Also, try altering the surface material that is being struck. How do these changes affect the crater? Is it possible to reinforce the Earth’s surface for future impacts? Why or why not? Using the concept of conservation of motion and energy, have students calculate the net increase of energy into the Earth system from an inbound object. Vary the speeds and masses of objects to determine which, if any, has a greater change in energy release. Theorize as to why a single large meteorite delivers more, less or the same amount of power and/or is more destructive than hundreds or even thousands of smaller ones of the same net mass or speed.

## Evaluation

- Students successfully identify existing impact craters on the Earth as well as other celestial bodies. Collect data and analyze their findings.
- Students construct reasonable facsimiles of impact craters using the provided material.

- Students measure, record, and analyze their findings from the impact activity.
- Students construct reasonable connections between simulations and research of real-world incidents.
- Students successfully write a short essay response in a reflective style about what they learned from this activity, and how this knowledge may be useful to the mitigation efforts of those studying Apophis.

### ***Cratering in your Classroom***

Impact cratering is a process found everywhere in the solar system except on the giant gaseous planets. Earth has been heavily impacted in the past, however erosion has removed most of the craters. Perhaps the finest surviving impact crater on Earth is the Barringer Meteor Crater near Winslow, Arizona. It is 1.2 kilometers (0.75 miles) across and 200 meters (650 feet) deep. It was formed about 49,000 years ago when a 50-meter (150 foot) nickel/iron meteorite struck the desert at a speed of 11 kilometers per second (25,000 miles per hour).

An examination of actual craters, almost any image of the Moon will do, will prepare the students for this activity. Just about all craters have deep central depressions, raised rims, and a blanket of ejected material surrounding them. You and your students can observe the Moon directly during daylight. Check your newspaper for the phases of the Moon and observe it in the afternoon during "first quarter" and in the morning during "third quarter." The Moon will be separated from the Sun by 90 degrees to the east (left) at first quarter and 90 degrees to the west (right) during third quarter. The large dark regions are the remains of very great impacts and many retain their circular boundaries. Binoculars on a tripod provide a spectacular view.

### **Procedures and materials**

You can create craters in the classroom with the following materials: A box, lined with a trash bag, with sides two to four inches high (the lid to photocopier paper boxes is perfect); enough flour to create a layer two to three inches deep with at least an inch of clearance to the box top; some dry (powdered) tempera paint (red or blue); spheres of different size and density: marbles, golf balls, ping-pong balls, bearings, etc.

Place the flour in the box, smooth, and firmly pack it (experiment with different firmnesses). Place a dusting of the paint powder over the flour (colored water in a spray bottle works, but not as well). Use the spheres to bombard the surface (one at a time) from varying heights. Look for classical cratering features: basin, raised rim, ejecta blanket (material excavated from the crater and dumped

around it, visible as white flour on the colored powder), and rays (material shot out at high velocity forming lines pointing directly away from the impact site).

Students should keep careful records and can do top and profile drawings of the craters and compare craters formed by different size projectiles, different velocities, and different angles of impact. Different size projectiles can be dropped from measured heights so that they will have common velocities. They should also remember that the quality of their tests is more important than quantity.

Use a millimeter scale (ruler) to measure the size, shape, and depth of craters. Record this data for later analysis.

After several craters, the flour and tempura can be mixed and re-smoothed without changing the white of the flour too much. Then, a new layer of tempura can be applied and additional experiments conducted. In real impacts, the impacting object is destroyed or broken up into small chunks. Of course, the marble will not do this and will remain whole in the crater.

Calculate the speed of your dropped objects. Speed equals distance divided by time:

$$s = d/t$$

Graph your results using a bar graph or scatter diagram.

Extrapolate and compare your simulations with the reviewed literature on impact craters and forecast the impact crater potential of the Apophis asteroid.

***Apophis asteroid data - 320 meters,  $4.6 \times 10^{10}$  Kg (46,000,000,000 Kg), 12.59 Km/s***

Write a reflective essay on your finding and experiences from this laboratory activity. Consider using the following vocabulary terms.

### ***Vocabulary***

#### **Central Peak**

A mountain found in the center of large craters. It is formed by a "rebound" of the rock at the impact site (the marble will be sitting there in this activity).

#### **Crater**

A (usually) circular depression in a surface caused by an impact.

**Ejecta**

Material tossed out of the crater.

**Ejecta Blanket**

Ejecta tossed out at low speed. The material lies like a blanket around the crater.

**Floor**

The interior of the crater. It is flat in large craters (the marble will be there in this activity).

**Rays**

Ejecta tossed out of the crater at high speed. The material forms long lines pointing directly away from the crater.

**Rim**

The raised edge of the crater. It is formed by the outward and upward compression of the crater walls, not ejecta.

**Resources**

<http://neo.jpl.nasa.gov/risk/a99942.html>

<http://www.barringercrater.com/>

<http://neo.jpl.nasa.gov/risk/>

<http://www.unb.ca/passc/ImpactDatabase/>

<http://www.solarviews.com/eng/tercrate.htm>

[http://www.armageddononline.org/99942\\_apophis\\_asteroid.php](http://www.armageddononline.org/99942_apophis_asteroid.php)

[http://en.wikipedia.org/wiki/99942\\_Apophis](http://en.wikipedia.org/wiki/99942_Apophis)