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Catalog No. AP7676
Publication No. 7676

# Investigating Impact Craters
## Student Laboratory Kit

## Introduction

Gaze at a full moon on a clear night and notice the circular features that can easily be seen. These circles are *impact craters,* depressions in the surface created when debris from space hit the Moon. In this activity, investigate factors that can affect the appearance of impact craters.

## Concepts

- Kinetic energy
- Meteorites
- Impact craters

## Background

Many objects in the Solar System, such as the terrestrial planets, other moons, and asteroids, exhibit impact craters. The object creating the crater is called an *impactor*. Most impactors are *meteoroids,* small rocky or metallic objects traveling through space. When a meteoroid enters the Earth's atmosphere, it is called a *meteor*. Meteors often disintegrate as they travel through the Earth's atmosphere, but a portion of some meteors may strike the surface. Any fragment of a meteor that survives the impact is called a *meteorite*. Since the Moon has no atmosphere, its surface is impacted ~~more~~ frequently than the Earth. In addition, without wind or water erosion, the features of lunar impact craters remain evident for a longer period of time. Scientists once thought most craters on the Moon originated from volcanoes, but by studying Earth's impact craters—such as Meteor Crater in Arizona—they have identified similar features on the Moon as impact craters.

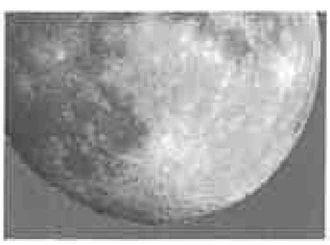

**Figure 1.** Impact crater rays

The kinetic energy of an object is equal to ½ $mv^2$, where $m$ = mass and $v$ = velocity. Since an impactor travels at a high rate of speed due to the acceleration of gravity, the impact event is usually explosive, which is why most impact craters are circular, no matter the shape of the meteorite. Only impactors that strike the surface at a very low angle form elongated craters. Most of the impactor matter is vaporized by high-pressure shock waves. The collision and explosion create a crater in which the target material is compressed, displaced, and ejected. The blanket of material that is thrown out of the crater—*ejecta*—is thicker nearer the crater. Some of the ejecta form a rim around the outer edge of the crater. Other ejected matter may form *rays*—streaks of fine material thrown out from the crater in a radial pattern like spokes on a wheel. When the crater ejecta material is more reflective than the surrounding landscape, the rays are clearly visible (see Figure 1).

## Experiment Overview

The purpose of this activity is to investigate factors that affect the diameter and depth of impact craters. The density of the impactor will be investigated in Part A, the diameter in Part B, and the speed of the impactor in Part C.

## Pre-Lab Questions *(Answer on a separate sheet of paper.)*

1. One variable that will be investigated is the density of the impactor. Density = mass/volume.
   a. The equation for the volume of a sphere is $V = 4/3\pi r^3$, where $r$ is the *radius*. Determine the volume of the 1.9-cm *diameter* spheres that will be used as impactors in Part A of the *Procedure* and record the volume for Data Table A on the Investigating Impact Craters Worksheet.
   b. Briefly describe how the density of each sphere used in Part A of the *Procedure* can be determined.

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2. In Part B of the *Procedure,* steel spheres with different diameters will be used as impactors.
   *a.* Complete the following statement, "If the diameter of a solid steel sphere is increased, then the mass of the sphere will (increase/decrease/remain the same) because ______________________________.
   *b.* Complete the following statement, "If the diameter of a solid steel sphere is increased, then the density of the sphere will (increase/decrease/remain the same) because ______________________________.

## Materials

Balance

Box or tray

Ceramic ring magnets, 2

Dish, plastic, 14 cm × 14 cm

Glass sphere, 1.9-cm diameter

Meter stick

Polystyrene sphere, 1.9-cm diameter

Ruler, metric, 15 cm

Sand, 500 g

Steel spheres, 1.3-cm, 1.6-cm, 1.9-cm diameter

## *Safety Precautions*

*Wear safety glasses during this investigation. Please follow all laboratory safety guidelines.*

## Procedure

### Part A. Density of Impactor

1. Place the plastic dish in the center of a shallow box or tray.
2. Carefully fill the dish to the top with sand.
3. Gently shake the dish back and forth to level the sand. Use the metric ruler to smooth the sand so it is even with the top of the dish (see Figure 2).

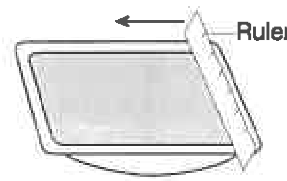

**Figure 2.**

4. One team member should hold the meter stick vertically so the zero end is on the work surface.
5. Another team member should hold the 1.9-cm diameter polystyrene sphere 30 cm above the top of the sand. *Note:* Be sure to measure 30 cm from the top of the sand, not from the work surface.
6. Drop the sphere onto the sand.
7. Carefully remove the sphere from the sand, taking care to disturb the crater as little as possible.
8. Use the metric ruler to measure the diameter of the crater from the top of the "rim" on one side to the top of the "rim" straight across.
9. Record the diameter on the Investigating Impact Craters worksheet in Data Table A.
10. Measure and record the depth of the crater. *Note:* If the zero mark on the ruler is not at the edge, the ruler will need to be carefully inserted into the sand until the zero mark is even with the bottom of the crater.
11. Repeat steps 3–10 for two more trials with the same sphere.
12. Repeat steps 3–11 with the 1.9-cm glass sphere.
13. Repeat steps 3–11 with the 1.9-cm steel sphere. *Note:* Use the two disk magnets to remove the steel sphere from the sand without disturbing the crater (see Figure 3).

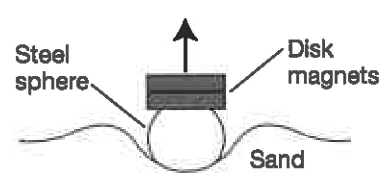

**Figure 3.**

14. Mass each sphere from Part A on a balance.
    *a.* Record the mass of each sphere in Data Table A.
    *b.* Calculate the density of each sphere using the volume calculated in *Pre-Lab Question* 1*a*.
    *c.* Record the density of each sphere in Data Table A.



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**Part B. Diameter of Impactor**

1. Level the sand in the dish as in step 1 of Part A.
2. One team member should hold the meter stick vertically so the zero end is on the work surface.
3. Another team member should hold the 1.3-cm steel sphere 30 cm above the top of the sand. *Note:* Be sure to measure 30 cm from the top of the sand, not from the work surface.
4. Drop the sphere onto the sand.
5. Use the two disk magnets to carefully remove the sphere from the sand, taking care to disturb the crater as little as possible.
6. Use the metric ruler to measure the diameter of the crater from the top of the "rim" on one side to the top of the "rim" straight across.
7. Record the diameter on the Investigating Impact Craters worksheet in Data Table B.
8. Use the metric ruler to measure the depth of the crater. *Note:* If the zero mark on the ruler is not at the edge, the ruler will need to be carefully inserted into the sand until the zero mark is even with the bottom of the crater.
9. Using the same sphere, repeat steps 3–8 to obtain data for two more trials.
10. Repeat steps 3–9 using the 1.6-cm steel sphere.
11. Repeat steps 3–9 using the 1.9-cm steel sphere.

**Part C. Velocity of Impactor**

1. Level the sand in the dish as in step 1 of Part A.
2. One team member should hold the meter stick vertically so the zero end is on the work surface.
3. Another team member should hold the 1.9-cm steel sphere 30 cm above the top of the sand. *Note:* Be sure to measure 30 cm from the top of the sand, not from the work surface.
4. Drop the sphere onto the sand.
5. Use the two disk magnets to carefully remove the sphere from the sand, taking care to disturb the crater as little as possible.
6. Use the metric ruler to measure the diameter of the crater from the top of the "rim" on one side to the top of the "rim" straight across.
7. Record the diameter on the Investigating Impact Craters worksheet in Data Table C.
8. Use the metric ruler to measure the depth of the crater. *Note:* If the zero mark on the ruler is not at the edge, the ruler will need to be carefully inserted into the sand until the zero mark is even with the bottom of the crater.
9. Repeat steps 3–8 for two more trials with the same sphere.
10. Repeat steps 3–9, dropping the same sphere from 45 cm above the sand.
11. Repeat steps 3–9 dropping the same sphere from 60 cm above the sand.



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*Name:* ______________________

# Investigating Impact Craters Worksheet

## Data Tables

**Table A: Density of Impactor**

**Drop height:** 30 **cm** **Volume:** 3.6 **cm$^3$**

| 1.9 cm Spheres | | | Crater Diameter (cm) | | | | Crater Depth (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Material** | **Mass (g)** | **Density (g/cm$^3$)** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** |
| **Polystyrene** | | | | | | | | | | |
| **Glass** | | | | | | | | | | |
| **Steel** | | | | | | | | | | |

**Table B: Diameter of Impactor**

**Drop height:** 30 **cm**

| Steel Spheres | | Crater Diameter (cm) | | | | Crater Depth (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Diameter** | **Mass (g)** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** |
| **1.3 cm** | | | | | | | | | |
| **1.6 cm** | | | | | | | | | |
| **1.9 cm** | | | | | | | | | |

**Table C: Velocity of Impactor**

**Mass:** 28.2 **g**

| 1.9 cm Steel Sphere | Crater Diameter (cm) | | | | Crater Depth (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| **Drop Height (cm)** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** | **Trial 1** | **Trial 2** | **Trial 3** | **Average** |
| **30** | | | | | | | | |
| **45** | | | | | | | | |
| **60** | | | | | | | | |

## Post-Lab Questions and Calculations *(Answer on a separate sheet of paper.)*

1. Calculate the average crater diameter and depth for each test and record the respective averages in the data tables above.
2. In general, how does the diameter of the crater compare to the diameter of the impactor?
3. What was the effect of the density of the impactor on the size of the crater?
4. Find two spheres of similar mass but different diameters and compare their results.
   *a.* Does the mass or the diameter of the impactor seem to have a greater effect on the diameter and depth of the crater?
   *b.* Explain your answer to 4*a* in terms of kinetic energy.
5. Compare and contrast features of the experimental impact craters to actual impact craters.



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