# Exploring Cratering Student Activity

In this activity, you will be exploring how the factors such as shape, mass, velocity of the impactor and the make-up of the materials being impacted influence crater size and shape.

Brainstorming Session:
Before you begin experimenting, everyone in the class needs to brainstorm as a group to come up with factors that might influence crater characteristics.

Remember that this in not the time to debate if an idea is good or not. Just think of as many things that you can think of that might influence the size and shape of an impact crater.

Have someone record all the factors that individuals come up with. You will need to make a list of these factors to use in Section 1 of this activity.

## Section 1. Unstructured Testing of Impact Factors

Begin by collecting materials to test one or two of the factors you came up with in your brainstorming session.

Your will need the following materials:

- A pan of impact material
- Two or three different objects to act as impactors from items supplied by your teacher
- One pair Safety glasses for each experimenter
- Ruler, string, thin piece of wire or piece of spaghetti pasta to make measurements
- A 2-meter long wood strip marked and notched at 50 centimeter intervals.
- Small scale (pan scale with weights or electric scale)
- Drop cloth
- A copy of Student Data Sheet A

When you have collected your materials, go to the next page.

Variables to be considered:

- Drop objects from different heights
- Drop objects of different masses
- Drop objects of different shapes
- Is the surface material packed down or loose

While performing your experiments:

- wear safety goggles at all times
- do all activities safely
- do not use excessive force to throw objects into the pans holding the material to be impacted

Follow this Procedure:

1. In your group, come up with some ways to test two or three factors listed by the class as possible influences on crater size.

2. As you test the factors you chose, record your findings, observations, and crater measurements in the table in handout Student Data Sheet A.

As a minimum the following information must be included:

- List object or impactor used in the top row.
- In the left-hand column state procedures used and type of material impacted
- In the right-hand column state variable tested, list observations and other data

3. Spread out a drop cloth and place the pan with impact material in the center.

4. You will have thirty minutes to do your experimenting and record the required data.

5x. Clean up and return all items to the materials table. Discuss as a class the findings of your experimentation.

Section 2. Time Trials

In this section of the activity, you will find the amount of time it takes for different objects to fall through one and two meter distances before impacting a surface.

One individual will drop different objects from a set of pre-selected impactors through a PVC guide. Another member of the team will need to be the timer and someone else to be responsible for recording the results of each trial run.

Collect the following materials needed for the time trials:

- Impact container with dampened sand
- Stopwatch
- Meter stick
- One set of pre-selected metal impactors
- Either a fixed vertical angle PVC guide stand or a variable angle PVC guide stand
- C-Clamp
- One set of three impactor guides one meter long or one set of three guides two meters long
- One pair of safety glasses for each experimenter
- Small scale (pan scale with weights or electric scale)
- Drop cloth
- A Student Time Trial Data Sheet handout

When you have collected your materials, go to the next page.

You are to conduct six time trials for each object and record your findings on the Time Trial Data Table handout. Take the average of these trials to obtain the time of descent for each object.

Be sure to be accurate in both your observations and calculations as an accurate time values will be very important in section three.

While performing your experiments:

- wear safety goggles at all times
- do all activities safely
- do not throw objects down the PVC tubes, let them freefall.

Follow this Procedure:

1. If you have the fixed PVC guide stand, your angle will always be 90 degrees.

If your team has the variable PVC guide stand, you are to perform your time trials at a 45-degree angle. Attach a C-Clamp on the protractor at the 45-degree mark to ensure a constant angle of impact.

2. Spread out a drop cloth and place the pan with impact material in the center.

3. Place one of the PVC tubes into the guide stand and secure it with rubber bands or twisties. Position the PVC tube so that the lower end is two centimeters above the material to be impacted.

Be sure to make careful measurements and maintain this distance through all of the time trials. Not keeping the distance consistent will give you worthless data and invalidate the numbers you will be computing after completing Section 3.

4. Note: Drop height and distance traveled may not be the same value for the variable PVC guide unit.

5. Designate a Dropper, Timer, and Recorder, and a person to help hold and steady the PVC tube.

The holder for the variable PVC stand needs to ensure that the tube is at 45 degrees before each release of the impactor.

More consistent and valid results will be obtained if the Dropper and Timer individuals remain the same for all of the time trial runs.

6. Find and record the mass of impactor to be used.

7. Measure and record the drop height and angle of impact.

8. The Timer needs to inform the Dropper when to let go of the impactor by saying “go” or “now.” Upon hearing this, the Dropper releases the impactor and the Timer stops the watch at the moment of impact.

Before each drop, make sure the surface to be impacted is smooth and level.

Practice a few times to get use to sequencing the stopwatch with release of the impactor and the impactor hitting the surface material.

9. After a few practice runs, start the actual time trails for your objects.

Do six trial runs for each impactor, record the results, compute and record the total time and average time for the impactor.

10. Repeat the above steps for each impactor.

When done with the time trials, clean up, return all items to the materials table, and discuss as a class your findings. All teams should swap the data from their time trails with each other. This information will be needed as you perform Section 3 and then answer the questions at the end of the activity.

Section 3. Structured Testing of Impact Factors
In this section you will make observations for all of the designated steel impactor objects and record the perceived facts into Student Data Sheet B.

Structured testing means that only one variable is tested or changed at a time.

As you will note, the procedures used in this section are almost the same as you did in Section 2. However, you will have more details to be critically observing as you perform your experiments in this section.

Your team will need to run a minimum of three trials for each variable being examined. It is critical to maintain the same 2 cm elevation of the PVC tubing above the surface to be impacted as you did for the time trials.

Remember to think about how the information you gain from your testing might have been used by the Deep Impact scientists as they planned to create a football size crater on the comet Tempel 1.

Possible variables to be tested:

- Impactor mass
- Impactor size
- Impactor Shape
- Height traveled
- Type of material impacted
- Firmness of material impacted
- Angle of impact

Things to measure and notice:

- Crater depth
- Crater diameter
- Crater shape
- Angle of impact
- Ejecta pattern
- Number & length of rays
- Distance traveled
- Time traveled
- Drop height
- Object mass
- Object shape

Materials Needed:

- Different impact materials in containers that have surface indicator lines attached
- One set of pre-selected steel impactors
- One set of three impactor guides one meter long or one set of three guides two meters long
- Either a fixed vertical angle PVC guide support or a variable angle PVC guide support
- C-Clamp
- Ruler, string, thin piece of wire or piece of uncooked spaghetti pasta to make measurements
- One pair safety glasses for each experimenter
- Felt tip Sharpie marker
- Small scale (pan scale with weights or electric scale)
- Impactor extractors
- Vernier type calipers or other size-measuring apparatus
- Drop cloth
- Student Data Sheet B

When you have collected the required materials go to the next page.

While performing your experiments:

- wear safety goggles at all times
- do all activities safely
- do not throw objects down the PVC tubes, let them freefall

Procedure:

1. If your team has the variable PVC guide stand, you are to perform your time trials at a 45 degree angle. A C-Clamp placed at the 45 degree point on the protractor will ensure a consistent angle for positioning the PVC tube.

If you have the fixed PVC guide stand, your angle will always be 90 degrees.

2. Select one of the steel impactors to be tested and the correct diameter PVC tube for it.

3. Spread out a drop cloth and place the pan with impact material in the center.

4. Place the PVC tube into the guide stand and secure it with rubber bands or twisties. Position the PVC tube so that the lower end is two centimeters above the material to be impacted.

Be sure to make careful measurements and maintain this distance through all of the time trials. Not keeping the distance consistent will give you worthless data and invalidate the numbers you will be computing after section.

5. Note: Drop height and distance traveled may not be the same value for the variable PVC guide unit.

6. Designate a Dropper, Timer, Recorder, and a person to hold and help steady the PVC tube.

The holder for the variable PVC stand needs to ensure that the tube is at 45 degrees before each release of the impactor.

More consistent and valid results will be obtained if the Dropper and Timer individuals remain the same for all of the time trial runs.

7. Determine what variable is to be tested.

8. Find and record the mass of impactor to be used.

9. Measure and record the diameter or length of the impactor used.

10. Measure and record the drop height and angle of impact.

11. To allow more time for testing different variables, you may want to use the times recorded from Section 2 for each specific impactor.

12. If you are going to time each drop in this section then the Dropper needs to inform the timer when they let go of the impactor by saying “go” or “now.” Upon hearing this, the Timer starts the stopwatch and stops the watch at the moment of impact.

13. Before each drop, make sure the surface to be impacted is smooth and level.

14. Make sure that the surface indicator lines are pulled to the side away from the impact point.

15. If the surface material will fall into the crater when the impactor is removed, leave the impactor in the crater to make your measurements for depth.

16. Tighten a surface indicator line so that it is over the crater.

17. Gently insert a piece of wire or uncooked pasta into the crater until you touch the top of the impactor. Mark the pasta with a felt tip pen where it crosses the surface line indicator.

If using a piece of wire, bend the wire where it crosses the surface line indicator. Measure the length that was in the crater and add the length or diameter of the impactor to find the crater depth.

18. Observe and record on Data Sheet B all the characteristics about your crater that the impact caused.

19. Remove the impactor; restore the surface to its original condition and conduct two more trial runs using the same impactor following steps 14 through 18 above.

20. Repeat steps 2 through 20 above until you have tested all of the impactors and recorded the results.

23. When you have completed testing all of the impactors clean up your area and return all items to the materials table.

24. Obtain some Factors that Influenced Cratering data sheets and summarize you findings from the information you recorded in the Student Data Sheets B.

When you have accomplished this you will ready to move to Section 4: Making Sense of the Data Gathered.

Section 4: Making Sense of the Data Gathered

Answer the following questions using the observations and information gathered and recorded in your data sheets,

1. Calculate the velocity of the impactor at the moment it struck the surface material using the formula $V_i = V_o + at$. $V_i$= velocity at impact; $V_o$ = initial velocity; a = acceleration due to gravity (9.8 $m/s^2$); t = time traveled,.

Calculate the velocity for each impactor used, applying the variables of height and angle of decent.

Do you find any patterns? Explain any patterns or variations you may find.

2. Calculate the kinetic energy of each impactor using the same parameters given in question #1, The formula for kinetic energy is $KE = ½ mv^2$. KE = kinetic energy; m = mass of object; v = the velocity of the object,.

Look for patterns and variations and explain why you think they occurred.

3. Calculate the potential energy of each impactor. Use the formula PE = mgh. PE = potential energy; m = the mass of the object; g = acceleration due to gravity; h = the height above the surface in meters,.

Seek out patterns and variations and explain why you think they occurred.

4. Noting the time it took each object to drop the released distance, how do you explain the identical time of each object for the vertical or 90 degree drop and the variations of times for the 45 degree angle drop?

5. Reviewing your data, compare the size of all the craters and the resulting ejecta patterns.

Describe what factors you think appear to have the greatest affect on producing craters and ejecta patterns that might provide scientists an opportunity to gather information about sub-surface materials.

6. Pick one of the surfaces you made craters in to answer the next question. As you changed variables, what affect did they have on shape of the crater and the resulting ejecta patterns?

For example, what happened when the distance traveled was doubled or the mass of the impact was increased? Of all the variables you changed, which variable had the greatest effect?

7. What information or techniques from this experiment could be applied to the challenge the Deep Impact scientists had in determining what characteristics their impactor should have to create a crate on Tempel 1?

8. What are some disadvantages in using a low energy impact experiment to try and obtain insights on how to construct a high energy impact event?

9. After answering all of the above questions and feel like trying a challenging math problem related to the activity you just completed, ask you teacher for the Extension Problem.