Research Question

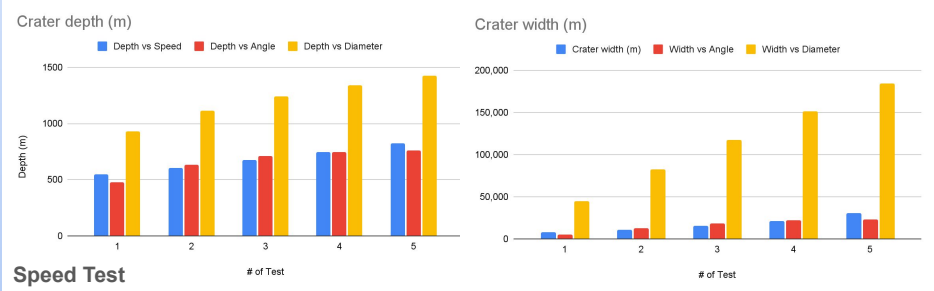
A Study of Meteorites and their Impact on the Lunar Surface

- To find a correlation between speed, velocity, and density to the impact of the crater that is left behind.
- If a meteoroid interacts with a planetoid head at a fast rate of motion and a high density; then it will impact the surface greater than a meteoroid with less density and less speed.
- Because a heavier meteoroid moving faster will hit the surface harder because it has more force than a lighter, slower one.

Procedure

- The first step is to establish the equations that I'll be using, for example density, speed, and the angle equations.
  - Density = mass/volume, speed = distance/time.
- The next step is to look at previous impact sites on the moon and establish a correlation between the theorized meteor that hit the Moon and what value.
- After that will run an experiment with a simulation with different levels of variables as listed above.
- Next will see if there's any correlation between the levels of the density, speed, angle, and impact measurements that hypothesized in the beginning.

Graph of Data



Speed Test

- Constants: Diameter (1000m) Angle (45 degrees) Projectile Density (Porous Rock) Target Density (Igneous Rock)

Angle Test

- Constants: Diameter (1000m) Speed (25km/s) Projectile Density (Porous Rock) Target Density (Igneous Rock)

Diameter Test

- Constants: Angle (45 degrees) Speed (25km/s) Projectile Density (Porous Rock) Target Density (Igneous Rock)

Results

The experiment showed that crater size depends on the speed, angle, and size of the meteor.

When speed increased from 5 km/s to 80 km/s, crater width grew from about 7,600 meters to over 30,000 meters and depth from 546 meters to 826 meters.

Changing the angle also made a difference. At the same speed, a shallow angle of 10° produced a crater about 4,986 meters wide. It should be oval in shape, while a straight-down angle of 90° produced one about 23,026 meters wide, more of a circular impact.

Meteor size had the greatest effect. A meteor 3,000 meters wide created a crater about 44,738 meters across, while one 15,000 meters wide created a crater over 184,000 meters across.

These results support the hypothesis that faster speeds, steeper angles, and larger meteors make bigger and deeper craters.

Introduction

Understanding meteoroid impacts involves examining how speed, direction, and density influence the resulting crater size. A meteoroid with greater mass and speed delivers more energy, creating a larger crater. Scientists investigate these impacts to gain insights into how craters form and what they reveal about a planet's geological history. This research is vital for understanding planetary surfaces and plays a crucial role in predicting and preparing for potential future impacts on Earth.

Background

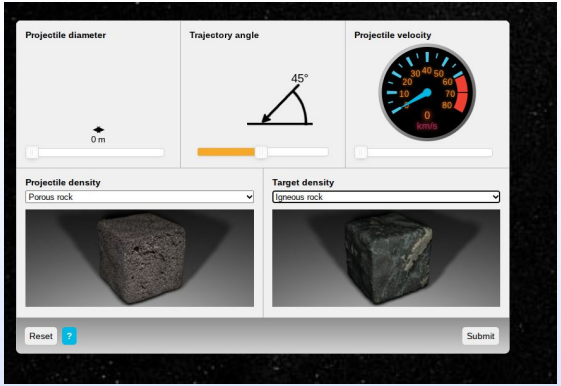
For thousands of years, the Moon has been a constant presence in the night sky, marked by dark blotches that are impact craters formed by meteorites striking its surface. Because the Moon lacks an atmosphere and has little erosion, these craters remain well preserved.

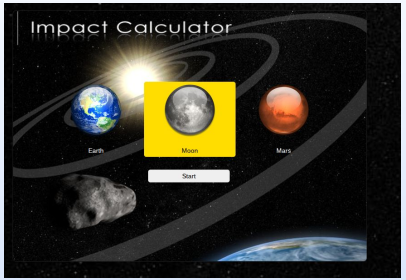
Although all craters form through similar impact processes, they vary in complexity: simple craters are small, smooth, bowl-shaped depressions, while complex craters are larger and feature central peaks, terraces, and flatter floors. Crater formation occurs in three main stages, compression, excavation, and modification, beginning with the transfer of energy from the impacting object, followed by the displacement and melting of surface material, and ending with the collapse and reshaping of the crater due to gravity.

The final size and shape of a crater depend on factors such as the meteorite's speed, angle, size, density, and the type of surface impacted, with faster or more direct impacts typically producing larger, more circular craters and shallower angles creating more elliptical ones. Ejected material can also form secondary craters around the main impact site.

This study focuses on how these factors influence crater formation on the Moon, using lunar surface images, existing data, and impact simulations to analyze simple impacts, while more complex craters and larger formations such as basins, massive craters from world-altering impacts, will be examined through direct observation and prior research.

Procedure





- Establish Key Equations
  - The formulas to use:
    - Density = mass / volume
    - Speed = distance / time
    - KE = 1/2mv^2
- Analyze Previous Impact Sites
  - Look at data from known lunar craters.
  - Find out what scientists think about the meteoroids that made them (their speed, density, angle, etc.).
- Set Up and Run Simulations
  - Use a simulation tool to model impacts.
  - Change variables like density, speed, and angle to see how they affect crater size.
- Look for Correlations
  - Compare simulation results and real crater data.
  - Check if changes in density, speed, or angle match predictions about crater size.
- Draw Conclusions
  - Summarize what found about how each variable affects impact craters.

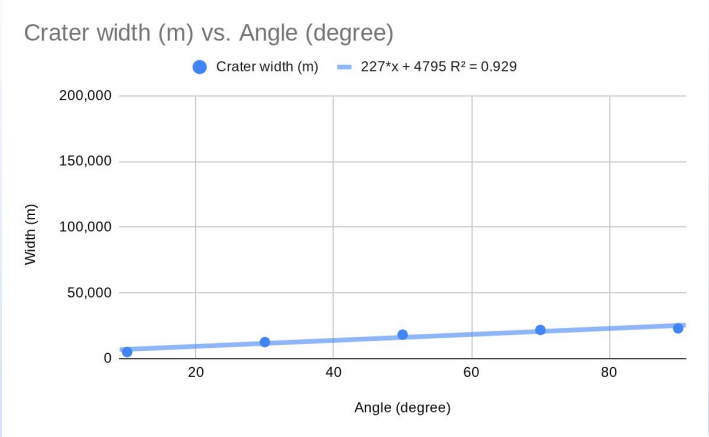
Speed (km/s)	Crater Depth (m)	Average	Crater Width (m)	Average	Precision
5	546-546-546	546	7,641-7,641-7,641	7,641	0
10	605-605-605	605	10,785-10,785-10,785	10,785	0
20	672-672-672	672	15,223-15,223-15,223	15,223	0
40	745-745-745	745	21,487-21,487-21,487	21,487	0
80	826-826-826	826	30,328-30,328-30,328	30,328	0
Angle	-	-	-	-	-
10	480-480-480	480	4,986-4,986-4,986	4,986	0
30	634-634-634	634	12,565-12,565-12,565	12,565	0
50	709-709-709	709	18,242-18,242-18,242	18,242	0
70	748-748-748	748	21,807-21,807-21,807	21,807	0
90	761-761-761	761	23,026-23,026-23,026	23,026	0

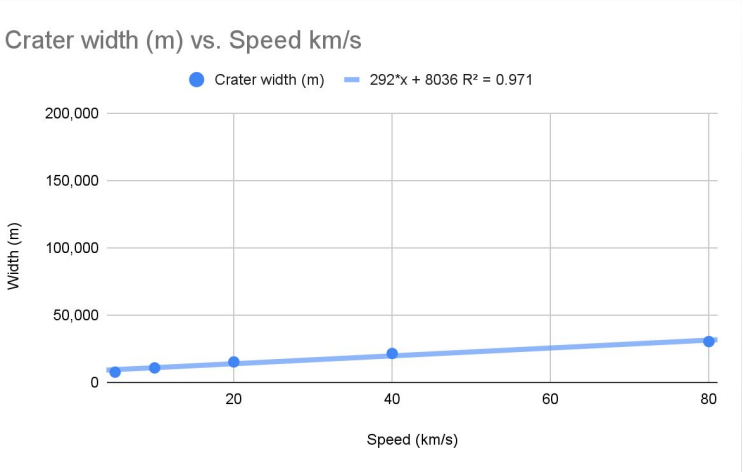
Data

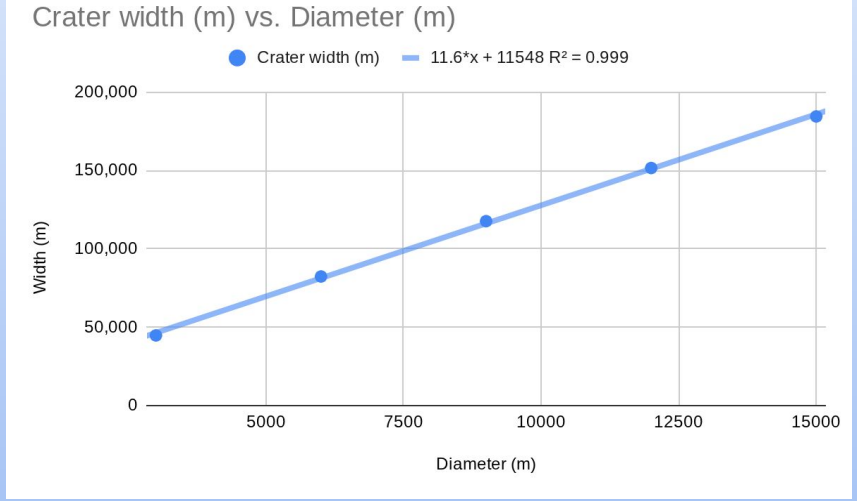
Diameter (m)	-	-	-	-	-
3000	929-929-929	929	44,738-44,738-44,738	44,738	0
6000	1,116-1,116-1,116	1,116	82,350-82,350-82,350	82,350	0
9000	1,243-1,243-1,243	1,243	117,672-117,672-117,672	117,672	0
12000	1,341-1,341-1,341	1,341	151,584-151,584-151,584	151,584	0
15000	1,423-1,423-1,423	1,423	184,484-184,484-184,484	184,484	0

- As speed increases:
  - Both average crater depth and width increase.
  - The relationship looks roughly linear, higher speed, bigger and deeper craters.
- As impact angle increases (from 10° to 90°):
  - Both average crater depth and width increase.
  - The effect is more dramatic at higher angles (closer to vertical impact).
- As projectile diameter increases:
  - Both average crater depth and width increase significantly.
  - The increase is much larger for width than for depth.
- All three variables (speed, angle, diameter) positively affect both crater depth and width.
  - The effect on width is especially pronounced with larger diameters.

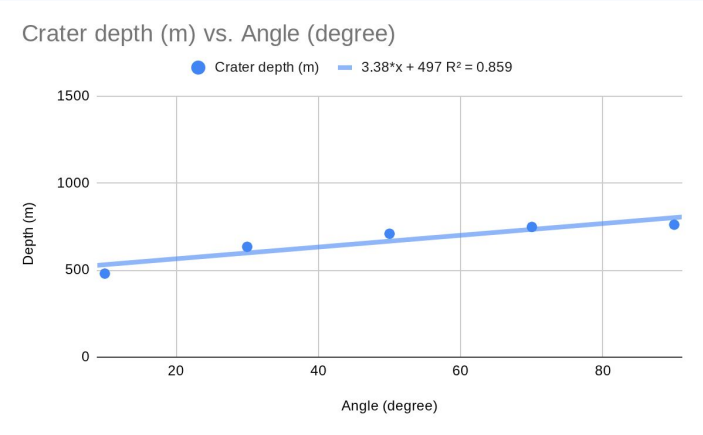
Graphs (Width)

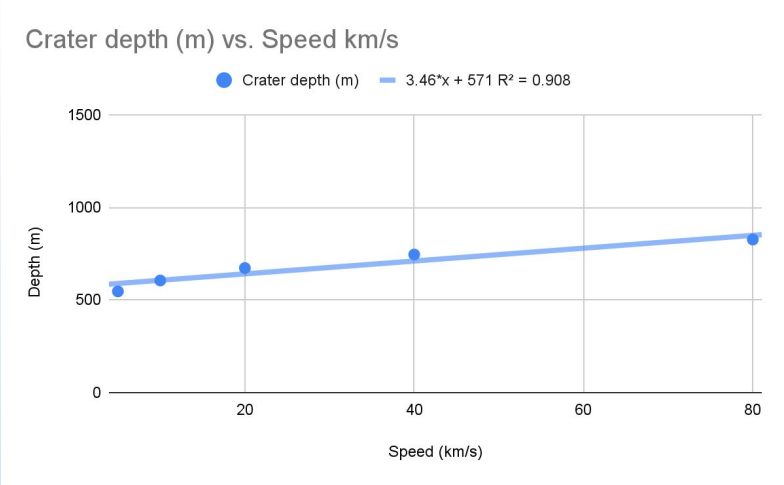


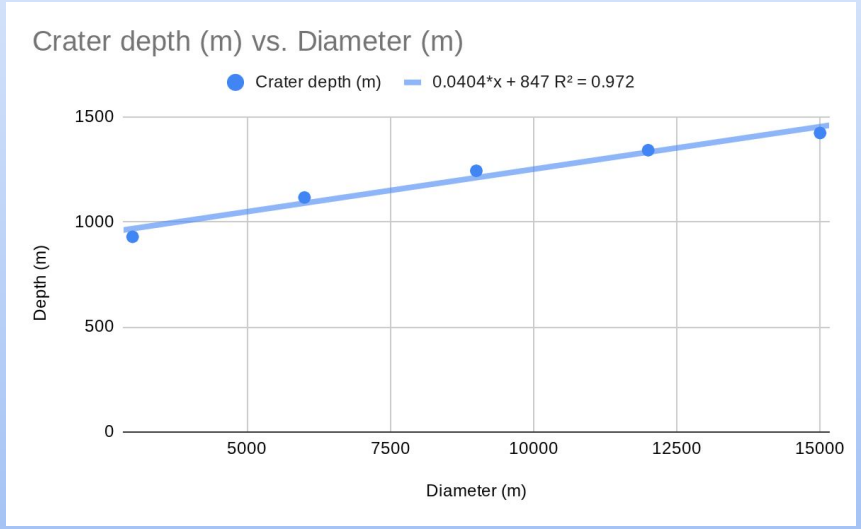




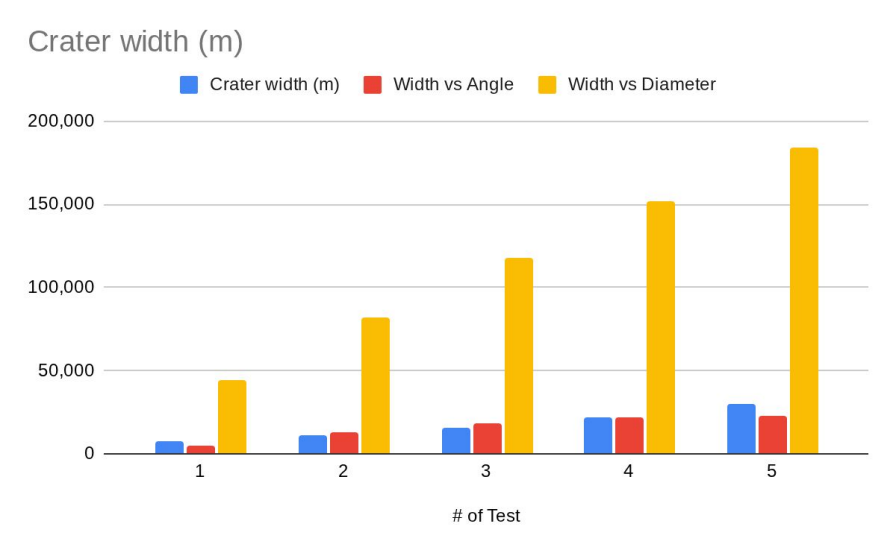
Graphs Continued (Depth)

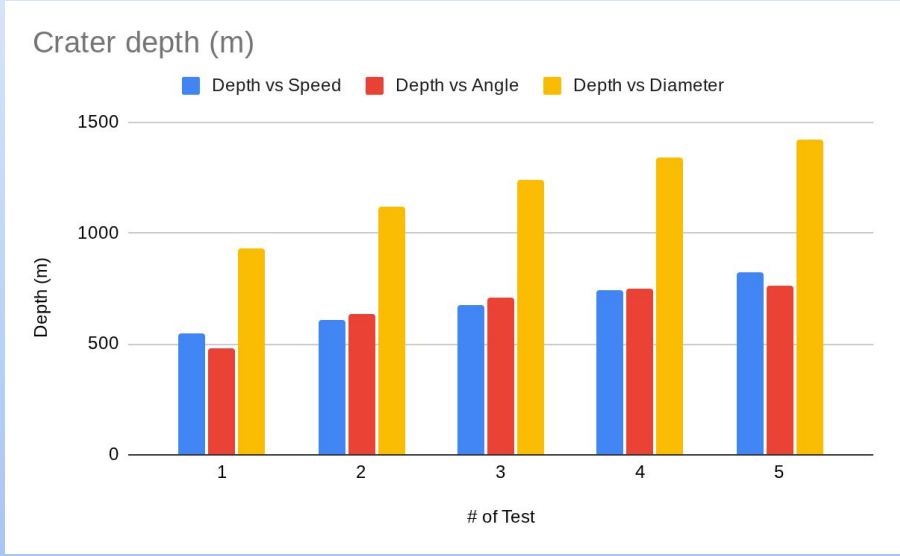






Graphs Continued (Comprehensive)





Conclusion

The experiment found that crater size changes based on how fast, how big, and at what angle a meteor hits. When speed went from 5 km/s to 80 km/s, craters got much wider (from about 7,600 m to over 30,000 m) and deeper (from 546 m to 826 m). The angle matters too: a shallow angle (10°) made a smaller, oval crater (about 4,986 m wide), while a straight-down hit (90°) made a much bigger, round crater (about 23,026 m wide). The size of the meteor had the biggest effect, larger meteors made much larger craters. For example, a 3,000 m meteor made a 44,738 m crater, but a 15,000 m meteor made one over 184,000 m wide. So, faster, steeper, and bigger meteors create bigger and deeper craters.

The data supported my hypothesis that speed, velocity, and density affect the size of impact craters. The results showed that higher impact speeds made bigger craters, and larger objects created deeper and wider craters. These patterns were clear and consistent in all trials. However, the experiment had some limits, like using a simulator that didn’t include all real-life factors and possible small measurement errors. To get better results, future experiments should use more realistic simulations or actual lunar images.

Reference

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Sullivan, W. (2025, August 7). Meteorite strikes are the primary creator of the Moon's thin atmosphere, study finds. Meteorite Strikes Are the Primary Creator of the Moon's Thin Atmosphere, Study Finds. https://www.smithsonianmag.com/smart-news/meteorite-strikes-are-the-primary-creator-of-the-moons-thin-atmosphere-study-finds-180984835/ The thin atmosphere helps show the impacts of craters but also shows that impacts thin and more