



## Oh Hail the Elephant! Grades 9-12



### Introduction:

This lesson focuses on one of the world's unsolved problems in mathematics, which we have found students get very excited about. It involves Hailstone sequences and invites students to make their own conjectures and learn something about the history of mathematics.

### Agenda:

Activity	Time	Description/Prompt	Materials
Mindset Video	5 min	Play the mindset video.	Mindset Video
Hailstone Sequences	5 min	Introduce the activity <ul style="list-style-type: none"> <li>Discuss with students the word conjecture. A conjecture is a proposition that is consistent with known data, but hasn't been proven, yet! In science we use hypothesis. In maths we use conjecture</li> <li>Don't tell students the conjecture. See what they can discover!</li> </ul>	Student handout (optional) page 3. This handout is prepared for students to read the task on their own, if you would like them to read some of the interesting details of this event - or you could tell them about it instead.
Exploration	20 min	Ask students to explore the expression and generate their own data. What do they notice? What questions do they have?	Paper and pencil Student handout (optional) page 3
Class Discussion	10 min	Collect observations and student thinking	
Closing	5 min	Debrief the mindset messages for this activity.	



This problem introduces students to one of the world's unsolved problems in mathematics, which is, in itself very cool. It involves a sequence of numbers called a Hailstone sequence. It is called this because the numbers go up and down again. For example:

20 – 10 – 5 – 16 – 8 – 4 – 2 – 1

Hailstone Sequences follow these rules:

If a number is even, divide it by 2

If a number is odd, multiply it by 3 and add 1.

You may like to tell or remind students that hailstones go up and down too – they start in a cloud as drops of rainwater, then they are pushed higher in the atmosphere by wind where they freeze, sometimes several times, before eventually falling back to Earth. The number sequences are called hailstone sequences because they go up and down like this.

In mathematics people make conjectures – it is an idea that you think might be true but you do not know for sure. Conjectures are very important in mathematics, and it is really good to ask students to make conjectures in mathematics. In our youcubed summer school the students really enjoyed making conjectures which we put on the board.

To introduce the activity tell students about hailstones and ask them to make conjectures about the hailstone sequence, by starting at different numbers and seeing what happens.

In 1937 a mathematician called Lothar Collatz proposed that for any number you pick, if you follow the procedure enough times you will eventually get to 1. This then became known as The Collatz Conjecture. Since then lots of mathematicians have been trying to prove or disprove it. So far every number that has been tried has reached 1, and powerful computers have checked enormous numbers of numbers, but no one knows if there is a big number out there that might break the rule. So this is classified as an unsolved problem in mathematics.

This is Collatz' conjecture, but there are many other conjectures that students may have come up with.

In our youcubed summer camp the students were really excited to learn about problems in mathematics that are unsolved, or that took many hundreds of years to solve, such as Fermat's Theorem.

More information on Hailstone sequences and the Collatz conjecture can be found at:

<http://mathworld.wolfram.com/HailstoneNumber.html>

<http://mathworld.wolfram.com/CollatzProblem.html>

<https://pmm.nasa.gov/education/content/how-does-hail-form>

[https://en.wikipedia.org/wiki/Collatz\\_conjecture](https://en.wikipedia.org/wiki/Collatz_conjecture)



## Oh Hail the Elephant!

The problem you will work on today is one of the world's unsolved problems in mathematics, which is, in itself very cool. It involves a sequence of numbers called a Hailstone sequence. The sequence is called this because the numbers go up and down again, like this:

20 - 10 - 5 - 16 - 8 - 4 - 2 - 1

Hailstones do this - they start in a cloud as drops of rainwater, then they are pushed higher in the atmosphere by wind where they freeze, sometimes several times, before eventually falling back to Earth. The number sequences are called hailstone sequences because they go up and down like hailstones.



In mathematics people make conjectures - it is an idea that you think might be true but you do not know for sure. Conjectures are very important in mathematics, and making conjectures is something you can be doing as a math student.

Try working with some hailstone strings of numbers that have different starting numbers and make conjectures about what you find out.

A hailstone string follows these rules:

- If a number is even, divide it by 2.
- If a number is odd, multiply it by 3 and add 1.