SIGNIFICANT FIGURES, ACCURACY, AND PRECISION

Unit Overview

In science, it is extremely important to be accurate and precise in taking and reporting measurements. The focus of this unit is on significant figures, accuracy, and precision. Significant figures are factually known numbers, and are used in reporting quantitative data that you collect in an experiment. There are rules to follow in how to report quantitative data that you have measured. Accuracy and precision describe whether the data you have measured is correct or reproducible. This information will be especially helpful in the coming units, as you will have many labs and activities where accuracy and precision are key, and you will be reporting your data using significant figures.

Significant Figures

Even when collecting data as a part of an experiment, scientists must be aware of the proper method of reporting the data. The numbers used in scientific research are called significant figures. Significant figures are those numbers that are factually known for certain plus one estimated figure. The number of significant figures is determined by the tool(s) that the scientist uses. As an example, if a scale measures mass in kilograms, the scientist can only give his or her answers in kilograms. The scientist cannot say that something has a mass of 2-3 kg. All measurements must be given in exact kilogram increments. If a scale records in 100-gram increments, the scientist could report his or her findings to the nearest one-hundredth of a kilogram (ex: 7.62 kg). In this case, there are three significant figures. Even though the scale measures to a tenth of a kilogram, an object's mass may not lie exactly in tenth's place, so the mass can be estimated one further digit into hundredth's place. A calculation based upon measurement is only as accurate as the device that made the measurement.

The degree to which a measurement is accurate is expressed by the number of significant figures used in the numeric result. These are rules for dealing with numbers and calculations based upon measurement:

- All digits (1 to 9) are significant.
- Zeros between significant digits are always significant.
- Trailing zeros are significant only if the number contains a decimal point.
- Leading zeros used to place the decimal point are not significant.
- For multiplication and division: the answer has the same number of significant figures as the lowest measurement's significant figures.
- For addition and subtraction: the answer has the same number of decimal places as the measurement with the fewest decimal places.

Rules of Rounding in Science

- If the next number is greater than 5, the previous number is rounded up.
- If the next number is less than 5, the previous number is rounded down.
- If the next number is 5, and the previous number is even, keep the even number. If the third number is 5, and the previous number is odd, round up to the next even number.

Example Using Significant Figures and Rounding

If a distance measured is 1.45 meters, there are 3 significant figures.

If it takes a car 0.19 seconds to travel the given distance, there would be 2 significant figures.

Think of this: speed equals distance divided by time

$$S = d \div t$$
$$S = 1.45\text{m} \div 0.19\text{s}$$
$$S = 7.6315789$$

If a person wants to find the speed of the car, they need to divide the distance by the time. However, the scientist cannot give an answer using this many decimal places. The correct number of significant figures must be used.

As we look at the numbers used to calculate the speed, the distance has 3 significant figures while the time has only 2 significant figures. The correct amount of numbers to be used in determining the answer should match the fewest number of significant figures in the calculations used to solve the problem. In this case, the fewest amounts of significant figures is 2.

The answer, 7.6315789, must be rounded to only 2 numbers.

Since two numbers can be kept, one must look at the third number and determine how to round the second number.

The original extended answer was 7.6315789 and the third number in this case is three. This means the scientist needs to round down. The answer for the speed would be 7.6 showing 2 significant figures.

Practice: Given the following numbers, determine the number of significant figures the answer could be reported to.

1.	7.766	3 significant figures
2.	5.13	3 significant figures
3.	12.01	4 significant figures
4.	0.125	3 significant figures
5.	1000	1 significant figures
6.	145	3 significant figures

This one is a little tricky. Zeros have special rules. Sometimes they count, and sometimes they do not.

Rule 1: Zeros to the right of numbers do not count unless there is a decimal.

EXAMPLE		
500	The zeros do not count	1 significant figure
0.500	The zeros to the right count.	3 significant figures
500.	Since there is a decimal, the zeroes count.	3 significant figures

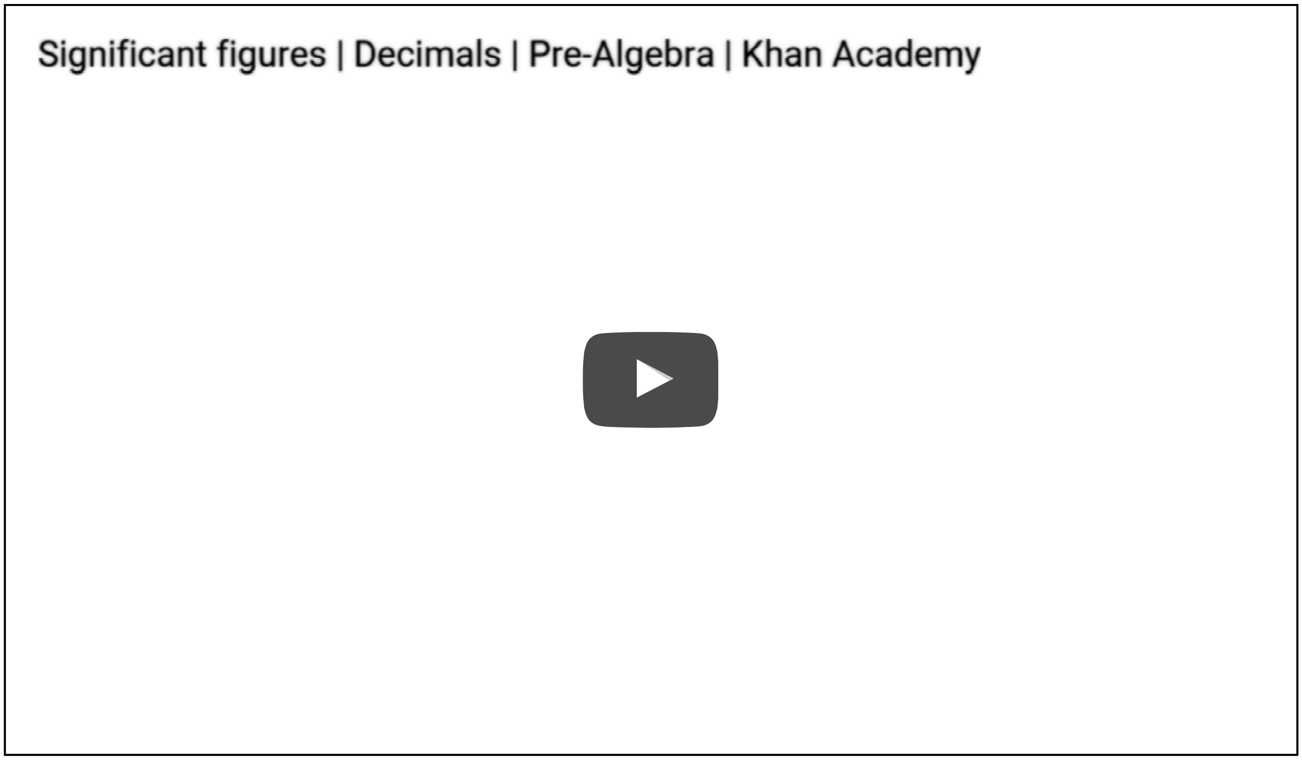
Rule 2: All zeros between numbers count.

EXAMPLE		
1001	All zeros count.	4 significant figures
100.05	All zeros count.	5 significant figures

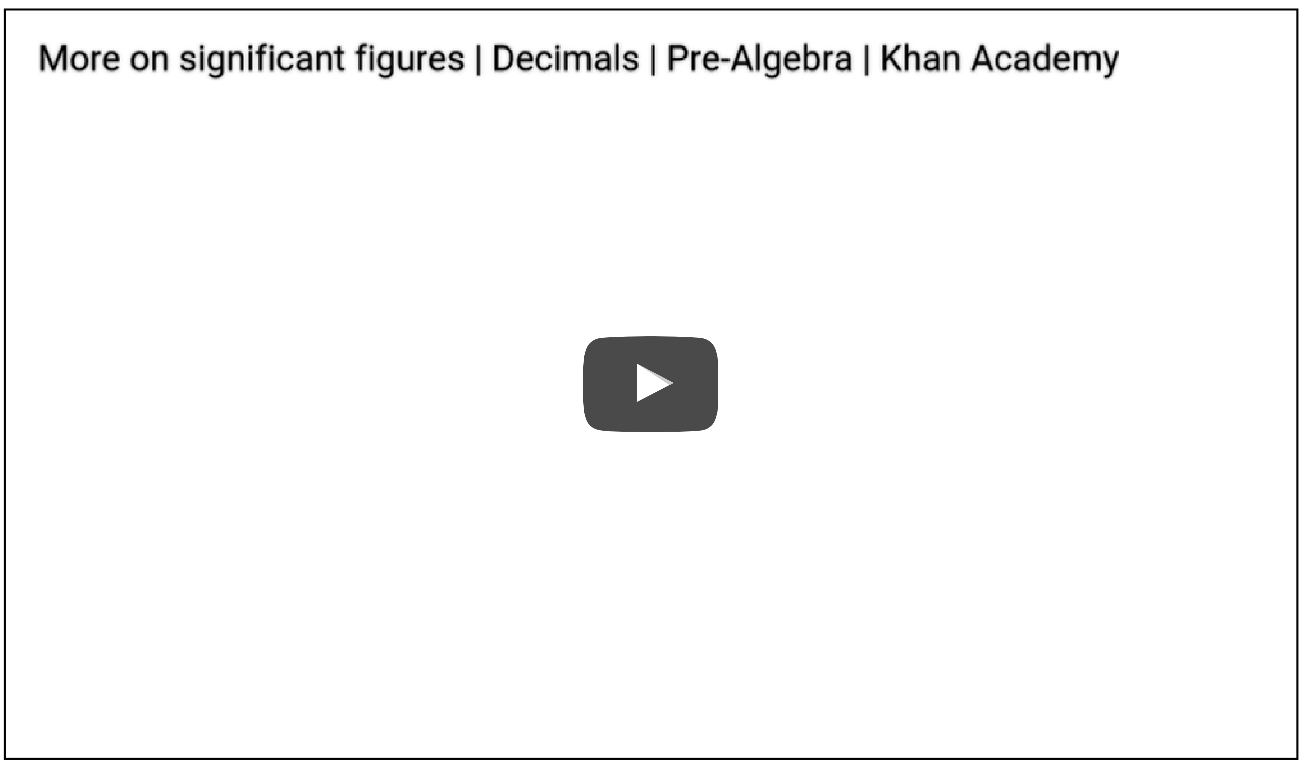
Video Clip: Significant Figures

Watch the following video clips for supplemental instruction on significant figures.

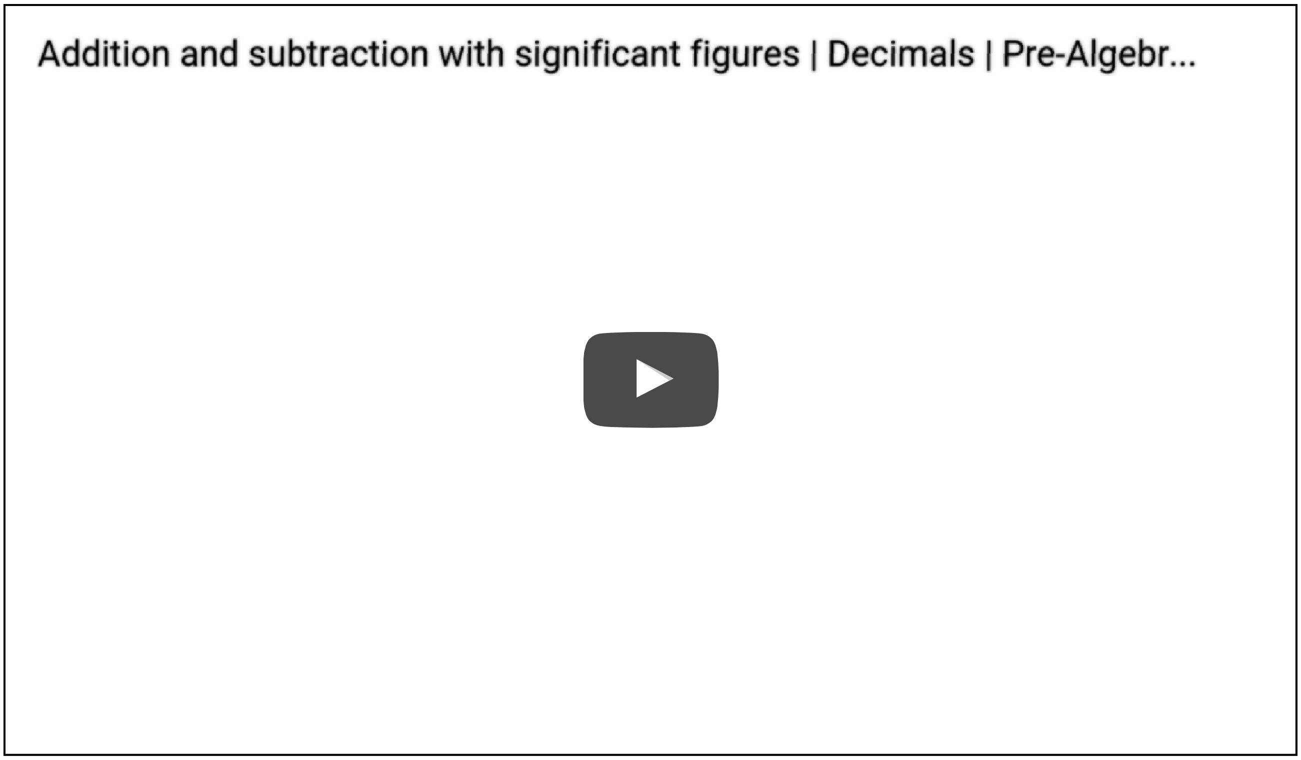
Introduction



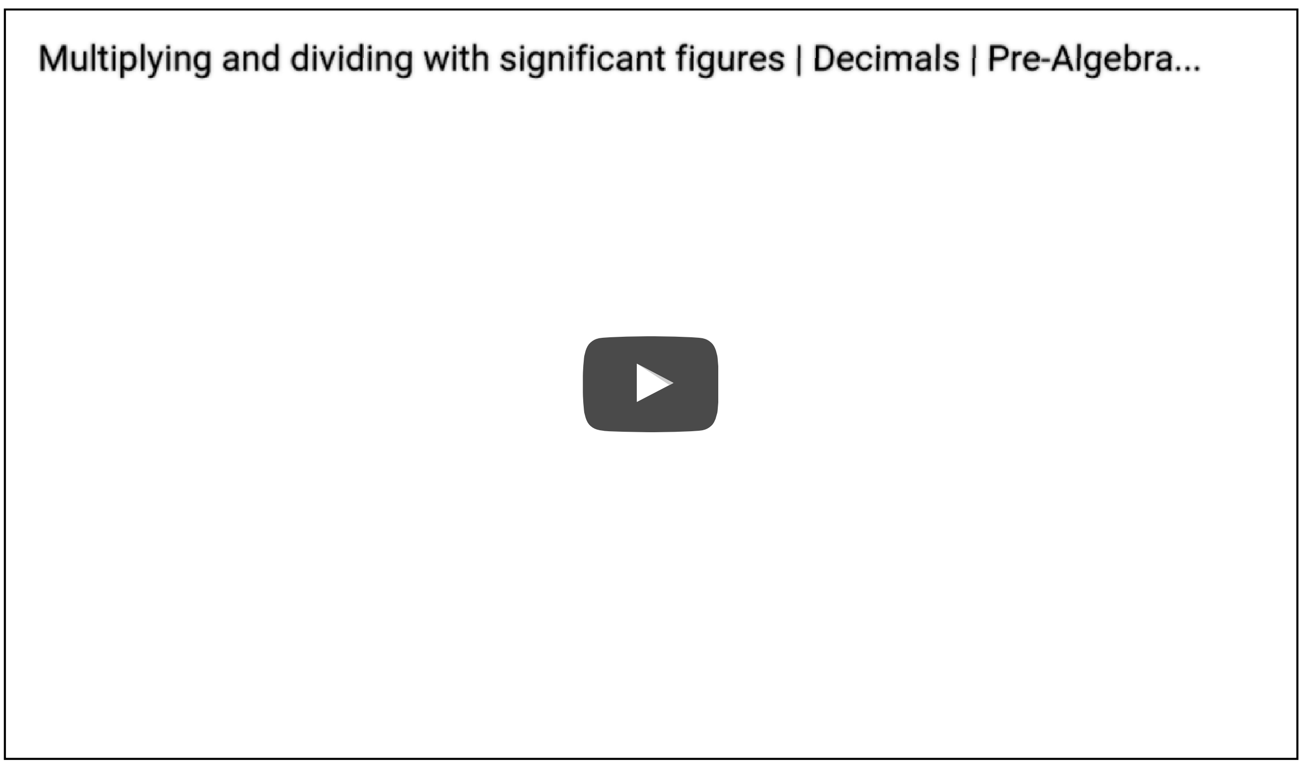
Rules



Addition and Subtraction



Multiplication and Division



Khan Academy: Significant Figures Practice

Click the link below to complete an activity evaluating significant figures.

https://www.khanacademy.org/math/arithmetic-home/arith-review-decimals/arithmetic-significant-figures-tutorial/e/significant_figures_1

QuickTime What are Scientific Measurements? (09:45)

Precision and Accuracy

Precision is how close the measurements are to each other. This is the reproducibility. In physical science it means "repeatable, reliable, getting the same measurement each time."

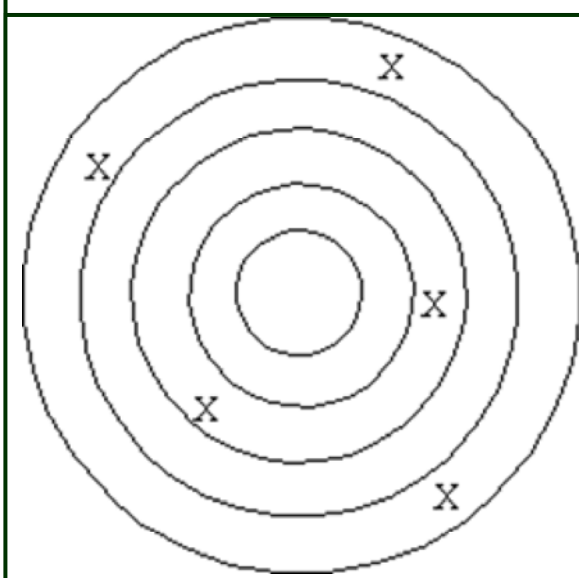
Accuracy is how close the measurement is to the actual value. In physical science it means "correct." A measurement is accurate if it correctly reflects the size of what is being measured.

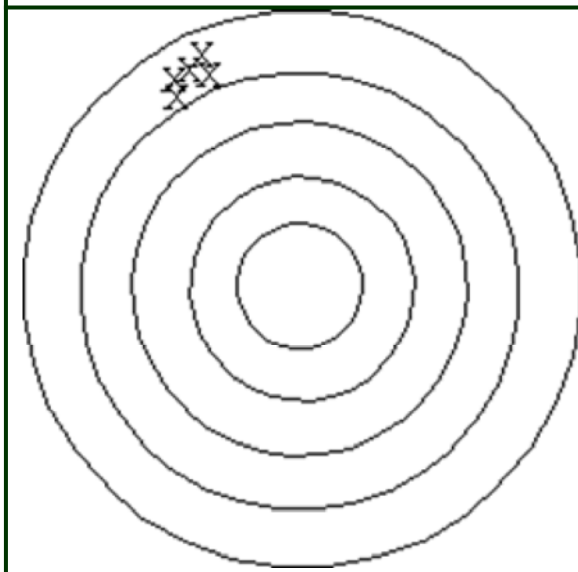
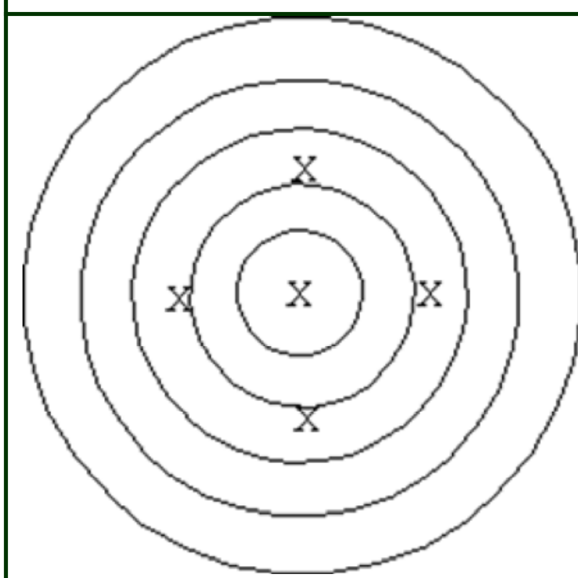
We can never make a perfect measurement. The best we can do is to come as close as possible within the limitations of the measuring instruments.

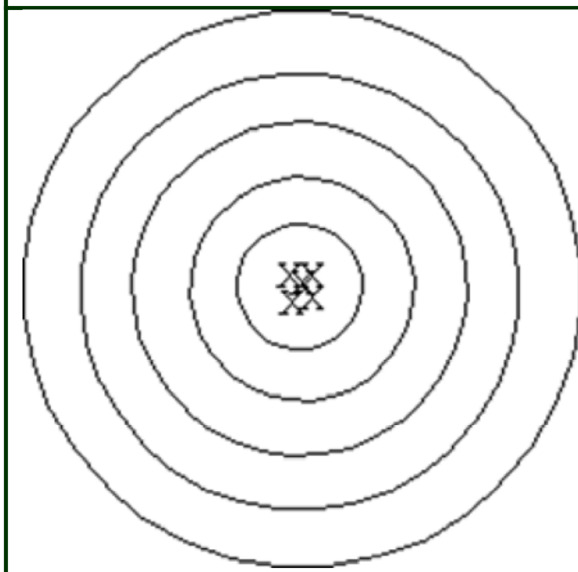
Let's use a model to demonstrate the difference.

Suppose you are aiming at a target, trying to hit the bullseye (the center of the target) with each of five darts. Here are some representative patterns of darts in the target.

Neither Precise nor Accurate



This is a random like pattern, neither precise nor accurate. The darts are not clustered together and are not near the bullseye.
Precise, Not Accurate

This is a precise pattern, but not accurate. The darts are clustered together but did not hit the intended mark.
Accurate, Not Precise

This is an accurate pattern, but not precise. The darts are not clustered,

but their 'average' position is the center of the bullseye.
Precise and Accurate

This pattern is both precise and accurate. The darts are tightly clustered and their average position is the center of the bullseye.

Precision and Accuracy Activity

Follow the link to complete “Is This Number Exact or Approximate? Is It Accurate or Precise?” activity. "**Username is vlastudent"** Once you log in, click “launch resource.” Complete handout associated with activity to submit to your teacher. Note: the activity references measurements for your classroom, but you can choose a room in your home to take your measurements

https://www.sascurriculumpathways.com/portal/#info/644

Now answer questions 1 through 15.