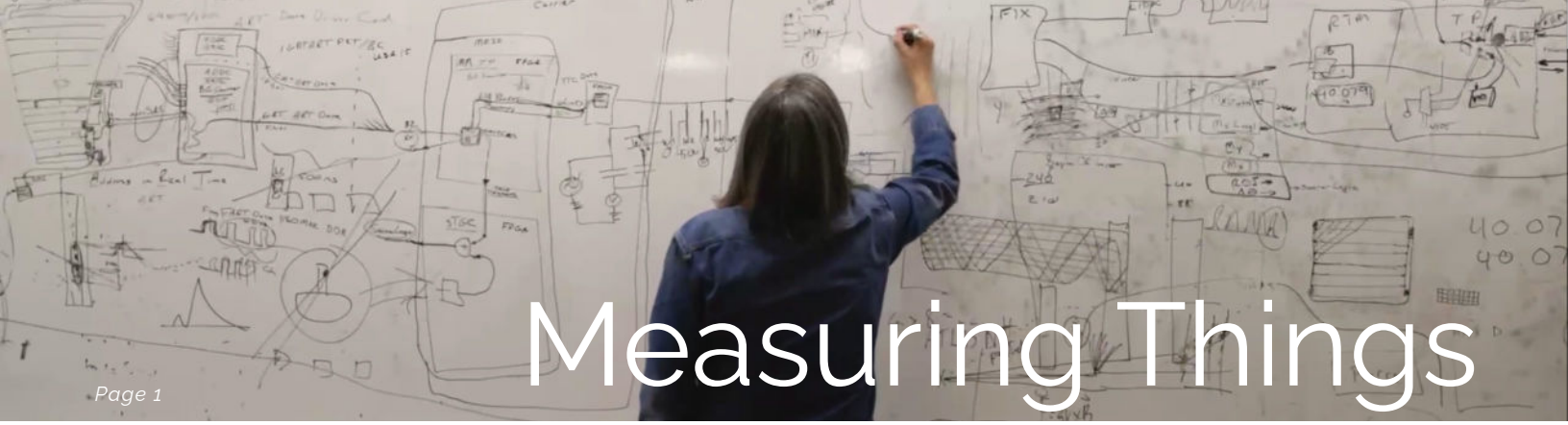

Measuring Things

LEARNING OBJECTIVES

Students will learn to:

- **Make measurements**
- **Collect and plot data**
- **Make inferences from data**
- **Experience some basics of statistics**

MATERIALS NEEDED

- **Measuring tape**
- **Paper and spreadsheet, or graphing calculator**

EDUCATOR'S NOTE

Veteran middle school science teacher Eileen Bendixen writes:

"One thing that I found surprising in my seventh grade science class was that students had not been taught to measure accurately. Some of them began their measurements from the one inch mark on the ruler. They did not stretch a tape measure tightly, or sometimes used it twisted. This is a great activity to teach students the importance of measuring accurately.

We had our students measure in metric. Until we did this beginning in the lower grades the students often did not know which side of the ruler to use. We explained that the United States is one of three countries who have not converted to the metric system, and that scientists around the world have decided to use the metric system in order to compare data."

Measuring things correctly is the key to finding an accurate result.

Melissa Franklin was the first woman to get a full professorship in the physics department at Harvard University. She is an experimentalist who loves to build instruments to measure elementary particles. She was part of a team at CERN, the giant particle accelerator near Geneva, Switzerland, that helped determine the mass of a new subatomic particle called the "top quark."

Melissa Franklin, Harvard physicist

View of CERN's massive particle accelerator.

Here's what Professor Franklin had to say in the second part of SEARCHING, "The Big & The Small":

"I like the act of measurement. I feel compelled to measure… The thing about physics is you can have all the interesting questions of a philosopher, but then you can actually measure something. The philosophers can't measure anything. I really feel bad for philosophers."

Activity

1) With the measuring tape, measure the heights of every student in the classroom. Students should first remove their shoes. Put your data in a spreadsheet, like this:

Name..... Height (in inches)
Morgan **65**
Bill..... **70**
Alice **62**
Joan **64**
The..... **72**
Martina **67**
Tania..... **61**

2) Now, compute the average height, which is the sum of all the heights divided by the number of people. In the example given above, that would be

<h> = (65+70+62+64+72+67+61)/7 = 65.9, which we will round off as **66**.

This average is also sometimes called the "mean."

Measuring Things

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Another interesting thing to know about measuring the properties of a group of items is how much the individual items differ from the average. A good measure of this "scatter" is to take each item and subtract it from the average, square that result, and then find the square root of the average of the squares. This final number, which measures the amount of scatter in the group of items, is called the "standard deviation," and denoted by **σ**.

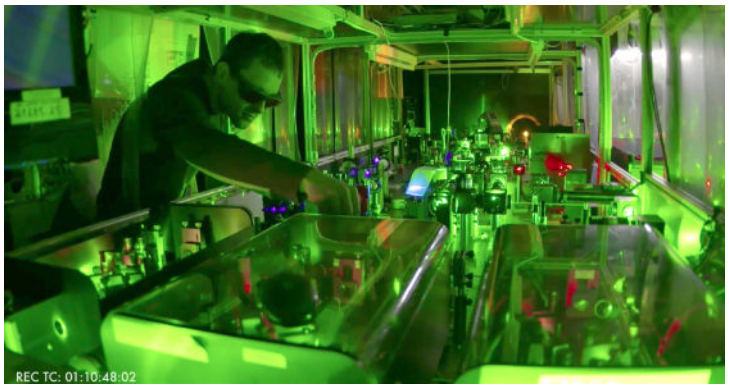
In the example above, we would compute the standard deviation in this way:

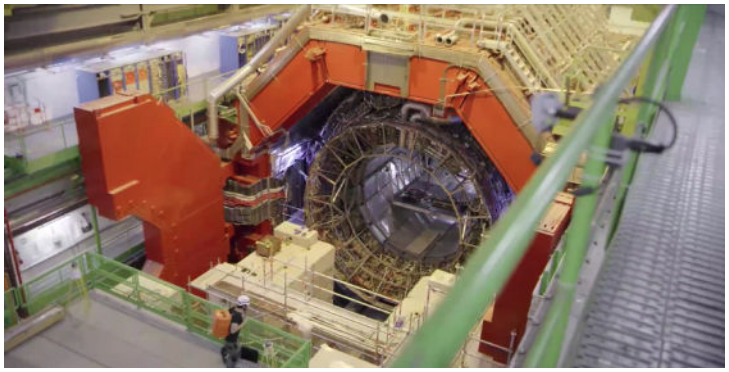
$$[\,(65-66)^2+(70-66)^2+(62-66)^2+(64-66)^2+(72-66)^2+(67-66)2+(61-66)^2\,]\,/7 = 14.1$$
$$\sigma = \sqrt{14.1} = 3.75$$

Discussion

Compare the data from your class to the data of other classes of the same grade level.

- **Was the mean similar or different?**
- **Compare your data to classes that are in a lower grade level.**
- **Compare your data to classes that are in a higher grade level.**
- **When you compare classes check the number of boys vs. girls. Is there a difference when there are more boys, or is there a difference if there are more girls?**
- **What can you say about the range of heights if σ is much smaller than <h>?**
- **What can you say if σ is much smaller than <h> or is not much larger than <h>?**
- **What would be the requirement on σ for you to be able to make an accurate prediction of the height of a student in another classroom?**





To get the most reliable results and avoid any equipment failures inside the particle accelerator, precision calibration and accurate measurements are critical.