HOW TO...

2 Make and Interpret Experimental Measurements

Name Date Class

(Unit 1 Chapter 1, Activity 1)

1. When scientists perform an experiment to measure a quantity, they never obtain a true (or exact) value. There is always some uncertainty associated with a measurement. Therefore, scientists always report a best value, not an exact value, for the measurement.
2. The goal of making good measurements is to reduce the amount of uncertainty, so that the best value is as close to the true value as possible. To do this, you need to design an appropriate experimental procedure and follow it very carefully.
3. Each measurement of a quantity may give a value that is either higher or lower than the true value. Therefore, it is common to make many measurements (called multiple trials), and then calculate the average of the measurements. This average is reported as the best value.

   To calculate the average you add up all the measured values, then divide by the number of trials. For example, if there are three trials:

$$\textbf{Average} = \frac{\textbf{Trial 1} + \textbf{Trial 2} + \textbf{Trial 3}}{\textbf{3}}$$

4. Sometimes one of the measured values is very, very different from the other values. This is called an outlier. If there is a good reason to believe that it is due to a major blunder in measurement, then you should ignore its value when determining the best value.
5. Because there will always be a variation in the values you obtain when making multiple measurements of a quantity, you need a procedure to report the uncertainty associated with your best value. After removing any outliers from your data, you calculate the uncertainty by subtracting your lowest measured value from your highest measured value, and then dividing this difference by two. That is:

$$\textbf{Uncertainty} = \frac{\textbf{Highest measured value} + \textbf{Lowest measured value}}{\textbf{2}}$$

   The value of the uncertainty then tells you by how much the true value may be higher than, or lower than, the best value.

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Example:
Imagine a student measured the time for 20 back and forth swings of a pendulum. Her results for four trials, including her values for the best value and uncertainty that she calculated using the above procedure are in the following table. Check the math to make sure the best values and uncertainty calculations are correct.

	Time for 20 Swings (s)
Trial 1	38
Trial 2	42
Trial 3	40
Trial 4	42
Best Value	40.5
Uncertainty	2

She would then report her results as follows:

"The best value is 40.5 s with an uncertainty of 2 s. This means that the true value is probably within the range between 38.5 s and 42.5 s."

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