NAME: _____DATE: _____ Period: _____

Uncertainty of Measurement Activity

PURPOSE
To measure the same object(s) with different tools in order to understand the difference between certain (known) and estimated digits.
To explain the difference between numbers in MATH and SCIENCE.

BACKGROUND
Previously, you may have thought of measurements as numbers just like the numbers used in math problems. In a math problem, an answer of 10 would be exactly the same as an answer of 10.0; an answer of 2.3 would equal an answer of 2.300. However, these equivalencies are not true in science.

Numbers in science are not arbitrary or just made up as they often are in math problems. All numbers in science problems come from measurements. Since no measuring instrument can be perfectly accurate, scientific measurements always include a degree of error or uncertainty.

In general, the smaller the divisions or increments on the scale of the instrument, the more accurate a measurement can be. Thus, a thermometer divided into increments of 1 degree would be more accurate than a thermometer with only 10-degree increments. The number of digits included in a measurement should indicate the accuracy of the instrument used. For instance, a measurement of 10.0°C was made with a more accurate thermometer than one which gave a measurement of 10°C. The 10.0°C means that the experimenter is sure that the temperature is between 9.5°C and 10.5°C. The 10°C measurement means the experimenter could only be sure that the temperature was between 0°C and 20°C.

To be as accurate as possible, **when making scientific measurements, always record all the digits which are certain, then estimate and record the next digit.** This method allows you to use instruments properly for scientific measurement.

MATERIALS
metric ruler with mm markings
paper decimeter and centimeter rulers
the line segment below

PROCEDURE
1. Cut out the two paper rulers. Begin with only the decimeter ruler, setting the other two aside.
2. Use the decimeter ruler to find the length of the line segment as accurately as you can.
3. Record your measurement in Data Table 1, and put the decimeter ruler away. Ignore the columns for *Conversions* at this time.
4. Next, use the centimeter ruler to measure the same line. Record the measurement in Data Table 1, and put the centimeter ruler away.
5. Finally, use the millimeter ruler to measure the line. Record data in Data Table 1.
6. Obtain a numbered rock from your teacher. Determine the mass of your rock using the electronic balance, the triple beam balance, and the four beam balance. Record data in Data Table 2, ignoring the columns for *Conversions* at this time. Return rock when finished.

DATA TABLE 1

	Length	*Conversion*	*Conversion*
Length of line segment with dm ruler	dm	*cm*	*mm*
Length of line segment with cm ruler	cm	*dm*	*mm*
Length of line segment with mm ruler	mm	*cm*	*dm*

DATA TABLE 2

Rock # _____	Mass	*Conversion*	*Conversion*
Mass of rock with electronic balance	g	*kg*	*mg*
Mass of rock with triple beam balance	g	*kg*	*mg*
Mass of rock with four beam balance	g	*kg*	*mg*

QUESTIONS and ANALYSIS

1. Using the decimeter (dm) ruler:
    a. How sure were you that the first digit (before the decimal) was a *0* and not a *1*? Explain how you are certain of this digit.
    b. How sure are you of the second digit in the same measurement?

2. Using the centimeter (cm) ruler:
    a. Were there any digits you estimated?
    b. If so, what was the estimated digit?
    c. Were there any digits you knew for sure (certain digits)? _____ If so, what were they?

3. Using the millimeter (mm) ruler:
    a. The certain digits were _____ because _____.
    b. The estimated digit was _____ because _____.

4. Suppose you measured a line that seemed to be exactly 15 mm using a millimeter (mm) ruler.
    a. Should there be an estimated digit in your measurement?
    b. If so, what would it be?

5. How many decimal places should be recorded for a measurement made with a triple beam balance? _____ How many decimal places should be recorded for a measurement made with a four beam balance? _____ How do you know how many decimal places to record for a measurement made with an electronic balance?