Measurement Uncertainty Activities

Crank-Three-Times Example

Suppose that you calculating the density of a metal object by measuring the object's volume and mass. When recording your measurements you will record the measured value followed by either the specified value for the measurement uncertainty or a reasonable estimate. For example:

volume: 2.75 ± 0.25 cm^3
mass: 54.2 ± 0.1 g

Density is mass / volume. To calculate the measurement uncertainty of the calculated volume, you need to account for the uncertainty of your volume and mass measurements. There are several approach to do this; we will use the Crank-Three-Times method. The first calculation is the nominal value. This is calculated using the measured values of each measurement. For example:

density = 54.2 g / 2.75 cm^3 = 19.709 g/cm^3

The second calculation is the smallest value based on the uncertainty of the measurements. This is calculated using either the measured values plus or minus the uncertainty, depending on the calculation. For example:

smallest density = 54.1 g / 3 cm^3 = 18.03 g/cm^3

(subtracting the uncertainty from the mass measurement and adding the uncertainty to the volume measurement results in the smallest calculated density).

The third calculation is the largest value based on the uncertainty of the measurements. For example:

largest density = 54.3 g / 2.5 cm^3 = 21.72 g/cm^3

(adding the uncertainty to the mass measurement and subtracting the uncertainty from the volume measurement results in the largest calculated density).

You would express the calculated density as 19.709 (+2.011 –1.679) g/cm^3

Station 1: Table Area

Using a meter stick, measure the length and width of the lab table. Record your measurements using the format of measured value ± uncertainty. Make a reasonable estimate of the uncertainty. Specify units.

width:
length:

Use the Crank-Three-Times method to calculate the area of the table. Record the area as the nominal value ± the calculated uncertainty:

Station 2: Classroom Volume

Using a meter stick, measure the length, width, and height of the classroom. Record your measurements using the format of measured value ± uncertainty. Make a reasonable estimate of the uncertainty. Specify units.

length:
width:
height:

Use the Crank-Three-Times method to calculate the volume of the classroom. Record the area as the nominal value ± the calculated uncertainty:

Station 3: Dime Volume

Using a ruler, make measurements that will allow you to calculate the volume of the dime. Record your measurements using the format of measured value ± uncertainty. Make a reasonable estimate of the uncertainty. Specify units.

Use the Crank-Three-Times method to calculate the volume of the dime. Record the area as the nominal value ± the calculated uncertainty:

Station 4: Time Light

Using a stopwatch, time how long the light is lit. Record your time measurement and enter it on a blank line in the spreadsheet at this station. Perform several trials.

Station 5: Cart on a Ramp

Using a stopwatch, have one group member call out every second after the cart is released from the line on the ramp. Measure the position of cart every second as it rolls down the ramp. Record your position measurements and enter them on a blank line in the spreadsheet at this station. Perform several trials.

Station 6: Pendulum Period

Using a stopwatch, measure how much time elapses as the pendulum swings from its highest point on one side to its highest point on the other and back. (This is called the period of oscillation). Record your measurement of the period. How could you reduce the uncertainty of this measurement? Do it. Perform several trials.