Data Analysis Exercises

(Adapted from materials created by

David M. Harrison, Dept. of Physics, Univ. of Toronto)

Before beginning these exercises, be sure to read:

MeasurementUncertainties.pdf.

If applicable, perform each exercise with both *python* and *Excel*.

A pair of dice

Roll a pair of dice 36 times and plot a histogram ofthe resulting distribution of values. Determine the mean, half-width, variance, and standard deviation of the resulting distribution of values, being sure that the python and Excel functions you use divide the sum of squared differences by N-1, not N, when calculating the variance and standard deviation. Do your experimental results agree with expectation?

Diameter of a coin (digital)

Determine the diameter of a coin with a digital caliper (is a coin perfectly round?). Report this diameter.

Diameter of a coin (analog)

Determine the diameter of the same coin with a ruler. Note that this is two measurements subtracted from one another. Use a digital caliper (open it as wide as it goes and measure the opening with the ruler) to estimate the accuracy uncertainty. Estimate, too, the systematic error caused by measuring a chord of the coin rather than the diameter. Report the diameter.

Compare the digital and analog diameter measurements. Do they agree?

Circumference to diameter ratio (analog)

Measure the circumferences and diameters of three different-sized rings or disks. Compare the ratios of each set of measurements for the different rings/disks. Do they agree with each other? Do all agree with the expected value?

Reaction time

After practicing a few times, attempt 15 times to stop a digital stopwatch at exactly 2.00 s. Record the actual stopped value each time. Determine the mean, standard deviation, uncertainty of the mean, and uncertainty of the standard deviation. Report the answer to the question: in attempting to stop the stopwatch at exactly 2.00 s, what was the time on the stopwatch when you stopped it?

Paper drop

Record the time it takes a standard 8.5 x 11 piece of paper to reach the floor after being released from

shoulder height. Be sure the paper is horizontal at release and hits nothing on the way to the floor. Use a digital stopwatch and repeat the measurement 20 times.

Histogram the results. What is the shape of the distribution? Justify your response. Report the time it takes for the paper to fall, noting the various sources of uncertainty in this measurement.

Absolute Zero

Taylor (An Introduction to Error Analysis, 1982, pg 160) provided the following data from pressure and temperature measurements of a gas. Assuming the gas to be ideal and at constant volume, estimate the value in Celsius of absolute zero. Take $\sigma_P \ll \sigma_T = 7^\circ\mathrm{C}$. Does the estimate agree with the accepted value?

Pressure [mm Hg]	**Temperature [°C]**
65	-20
75	17
85	42
95	94
105	127

Spring Scale

Calibrate a spring scale so that you are able to report the “true” mass for any reading on the scale. Does the scale reading drift over time?