# Measurement and Measurement Error

PHYS 1320 Fall 2002
Prof. Tunks & Olness

## Objectives

- To see how measurements and error analysis are a fundamental part of experimental science.
- To make some actual measurements and analyze the errors in them.
- To observe and understand the difference between accuracy and precision.
- To understand the nature of random and systematic errors.

## Equipment

Candle**,** ruler, "special" ruler, paper with closed curves, metal rod, material to be weighed (dry ice and alcohol) and triple beam balance.

## Procedure

1.Measure the length of the metal rods.
Using **only** the special ruler, measure the length of each piece 5 times. When you are finished, average the values to get a better measure of the piece's true length. Next, use your metal ruler to measure your pieces again. Measure 5 times as before and compute the average to refine your measured value. Make an "eyeball" estimate of your uncertainties.

2.Measure the height of the candle flame.
Light your candle and let the flame burn steadily for a minute or so. Use the metal ruler to measure the height of the flame. Make 10 measurements and try not to melt the ruler. Hold the ruler a small distance away from the flame. Record your measurements. Estimate for each measurement its . Identify the technique you used to find the uncertainty of your final answer. **Remember to write only a sensible number of significant figures**.

3.Measure your reaction time.
Your reaction time is the time that passes between some external stimulus and your first action. We will use an old method to measure your reaction time. A falling ruler will suffice. This is what to do.

a)Have your partner hold the regular ruler vertically, holding it by the top and having the zero point toward the bottom.
b)Place your thumb and forefinger at the ruler's bottom, surrounding the zero point. Be prepared to pinch the ruler as if it were to fall. **Rest your forearm on the lab table to steady your hand**.
c)Your partner will drop the ruler without warning.
d)Pinch and grab the falling ruler as fast as you can. Record the distance the ruler fell. This will tell you your reaction time.
e)Compute your reaction time using Galileo's formula: . The meaning of the symbols will be explained in lab.

Make 5 measurements and record the corresponding reaction times. Record **your** reaction times on **your** data sheet. Do not mix your times with your partners. This means you will make 5 measurements per person. Compute and record the individual 's for each measurement. Identify the technique you used to find the uncertainty of your final answer. Be sure that both you **and** your lab partner have your reaction times measured.

4.Measure the diameter of a closed curve.
Measure the diameter of the large closed curve. Measure this curve diameter across 6 *different* diameters of the curve. Record your measurements. Compute the average diameter. Estimate for each measurement its . Identify the technique you used to find the uncertainty of your final answer. Remember to write only a sensible number of significant figures.

5.Measure the mass of a cold material.
Go to the instructor's table with your partner, where you will be given a cup containing some alcohol and some crushed dry ice. Using the balance on the instructor's table, measure and record the mass of the cup 6 times, at 1 minute intervals. **Warning: The dry ice and alcohol mixture is quite cold. If you stick your fingers in the mixture you will feel much pain.**

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**Name**: _____ **Section**: _____

**Abstract**:

**Analysis**

1. Rod length

| Rod 1 | Special Ruler | | Plastic Ruler | |
|---|---|---|---|---|
| Measurement 1 | _____ | _____ | _____ | _____ |
| Measurement 2 | _____ | _____ | _____ | _____ |
| Measurement 3 | _____ | _____ | _____ | _____ |
| Measurement 4 | _____ | _____ | _____ | _____ |
| Measurement 5 | _____ | _____ | _____ | _____ |
| Measurement 6 | _____ | _____ | _____ | _____ |
| | | | | |
| Average Value | _____ | | _____ | |
| Uncertainty | _____ | | _____ | |

a)Explain the possible sources of error in this measurement?

b)How well did your measurements with the special ruler agree with those done with the plastic ruler? If there was a disagreement, what kind of error was it? Random or systematic? What caused this error?

2.Candle Flame

| | Flame height | |
|---|---|---|
| Measurement 1 | _____ | _____ |
| Measurement 2 | _____ | _____ |
| Measurement 3 | _____ | _____ |
| Measurement 4 | _____ | _____ |
| Measurement 5 | _____ | _____ |
| Measurement 6 | _____ | _____ |
| Measurement 7 | _____ | _____ |
| Measurement 8 | _____ | _____ |
| Measurement 9 | _____ | _____ |
| Measurement 10 | _____ | _____ |

Average Value _____

Uncertainty _____

a)Describe the possible sources of error in this measurement.

b)What might you do to get a better measurement of the flame's height?

3.Your reaction time

| | Distance | Time | (time) |
|---|---|---|---|
| Measurement 1 | _____ | _____ | _____ |
| Measurement 2 | _____ | _____ | _____ |
| Measurement 3 | _____ | _____ | _____ |
| Measurement 4 | _____ | _____ | _____ |
| Measurement 5 | _____ | _____ | _____ |
| Average value | _____ | _____ | |
| Uncertainty | _____ | _____ | _____ |

a)Describe the possible sources of error in this measurement and explain their relevance.

4. Closed Curve Diameter

Curve diameter

| | | |
|---|---|---|
| Measurement 1 | _____ | _____ |
| Measurement 2 | _____ | _____ |
| Measurement 3 | _____ | _____ |
| Measurement 4 | _____ | _____ |
| Measurement 5 | _____ | _____ |
| Measurement 6 | _____ | _____ |
| Average value | _____ | _____ |

Uncertainty _____

a)Describe the possible sources of error in this measurement.

b)What do the measurements tell you about the curve's diameter?

5.Mass of cold material.

| | |
|---|---|
| Measurement 1 | _____ |
| Measurement 2 | _____ |
| Measurement 3 | _____ |
| Measurement 4 | _____ |
| Measurement 5 | _____ |
| Measurement 6 | _____ |

a)Describe the possible sources of error in this measurement and their relevance.

b)Do you see any pattern in the measured masses? What is it?

6.Which of your measurements (metal rods, curve diameter, flame height, etc.) was the most uncertain? Why?

7.Which of your measurements (metal rods, curve diameter, flame height, etc.) was the least uncertain? Why?

8.Which measurements (metal rods, curve diameter, flame height, etc.), if any, suffered from systematic error? Explain.

**Conclusions**

Succinctly describe what you learned today.