

# Measurement and Error: The Height of Pupin

## Introduction

One of the primary activities of a scientist is comparing theories with empirical data. Scientists use theories to make predictions, which can be compared with experimental or observational results. In astronomy, theories are often (though not always) mathematical, and observations usually consist of quantitative measurements to be compared with theoretical calculations.

Repeating an observation several times often gives several slightly different results, even with the same method. The situation is even more confusing when different techniques give quite different results for the same quantity. How does a scientist determine which is the “real” answer, or whether their set of varying measurements for a quantity agree with a predicted value? This lab gives you a chance to explore these questions while performing your own measurements.

## 1 Precision, accuracy, and evaluating measurements

A couple of definitions that might be useful to you:

**Precision:** how close a measurement is to other measurements performed the same way.

**Accuracy:** how close a measurement is to the “true” value.

Examples: Lets say you measure the distance between two points several times. You get the following results: 2.15cm, 2.10cm, 2.11cm, 2.20cm, 2.13cm. We might choose the average value 2.14cm as our estimate of the true distance. The most discrepant measurement from the average was 2.20cm. This differs from the average by 0.6cm, so we might say the precision of our measurement is 0.6cm. There are other ways to calculate the precision of a measurement, so it’s important to specify how to determined precision when you report a value.

Now lets say that the ruler we used was poorly manufactured, and the true distance was 3cm. We would then say that the accuracy of the measurement was only 0.86cm. Note that it is usually impossible to know how accurate a measurement is, since all you have to compare it with may be other measurements.

Now discuss the following questions with your group and **briefly record your answers in your notebook.**

1. How would you define “experiment” (the noun)? How does an experiment differ from a measurement?
2. Let’s say you have two different methods of measuring a quantity and can repeat each one many times. How would you determine which method was “better” and what are your criteria?
3. Lets say you have the value of a quantity as predicted by a theory and a set of measurements of that value from an experiment. How would you go about determining if the experimental results agree with the theory?

## 2 Designing an experiment/measurement

### Materials

meter sticks, rulers, twine, scissors, tape, etc.

## Instructions

With your group come up with three methods of measuring the height of Pupin with the materials you have been provided, and **record the procedure for each in your notebook. Which methods do you expect to work best and worst? How will you determine the precision of your measurements?** Show your methods to a lab instructor before proceeding.

## 3 Measure the height of Pupin

### Materials

whatever you have selected

### Instructions

Once you have our approval, use each of your measurement techniques several times. You should end up with at least four numbers *per technique*. **For each technique determine a single value for the height of Pupin and the precision of that measurement.**

**Answer in your notebook:**

1. Which technique do you think worked best, and why?
2. How did you decide which technique worked best?
3. Determine a final value of the height of Pupin and the precision of that value.