Measurement and Significant Figures
What Is a Measurement?

• Quantitative observation
• Comparison to an agreed standard
• Every measurement has a number and a unit
A Measurement

• The unit tells you what standard you are comparing your object to
• The number tells you
  1. what multiple of the standard the object measures
  2. the uncertainty in the measurement
• Scientific measurements are reported so that every digit written is certain, except the last one, which is estimated
Estimating the Last Digit

• For instruments marked with a scale, you get the last digit by estimating between the marks
• Mentally divide the space into ten equal spaces, then estimate how many spaces over the indicator the mark is.
Estimation in Weighing

(a) Markings every 1 g
Estimated reading 1.2 g

(b) Markings every 0.1 g
Estimated reading 1.27 g
Estimating the last digit

• For the scale to the left, the smallest marked division is 0.2.

• Divide that by 10, so you will estimate to 0.02, 0.04, ...

• How would you report the measurement?
Digital Readouts

• These are easy!

• Report ALL digits you see, the instrument has already done the rounding for you.
Precision and Accuracy
Uncertainty in Measured Numbers

• Sources of error:
  – the experimental design/experimenter
  – Faulty or uncalibrated instruments
  – nature’s random behavior

• **Accuracy** is an indication of how close a measurement comes to the **actual** value of the quantity

• **Precision** is an indication of how close repeated measurements are to each other
  – how reproducible a measurement is
Precision

Do you get about the same value each time you measure?

- We determine the precision by evaluating how far the measurements are from each other
- You may miss the correct measurement, but you are consistent
Accuracy

How “right” is my measurement?

• We determine the accuracy of a measurement by evaluating how far it is from the actual value
Types of Errors

• Inaccuracy in measurement caused by **systematic errors**
  – errors we can fix by using more accurate instruments, or better technique or experimental design

• Imprecision in measurements is caused by **random errors**
  – errors that result from random fluctuations
  – no specific cause, therefore cannot be corrected