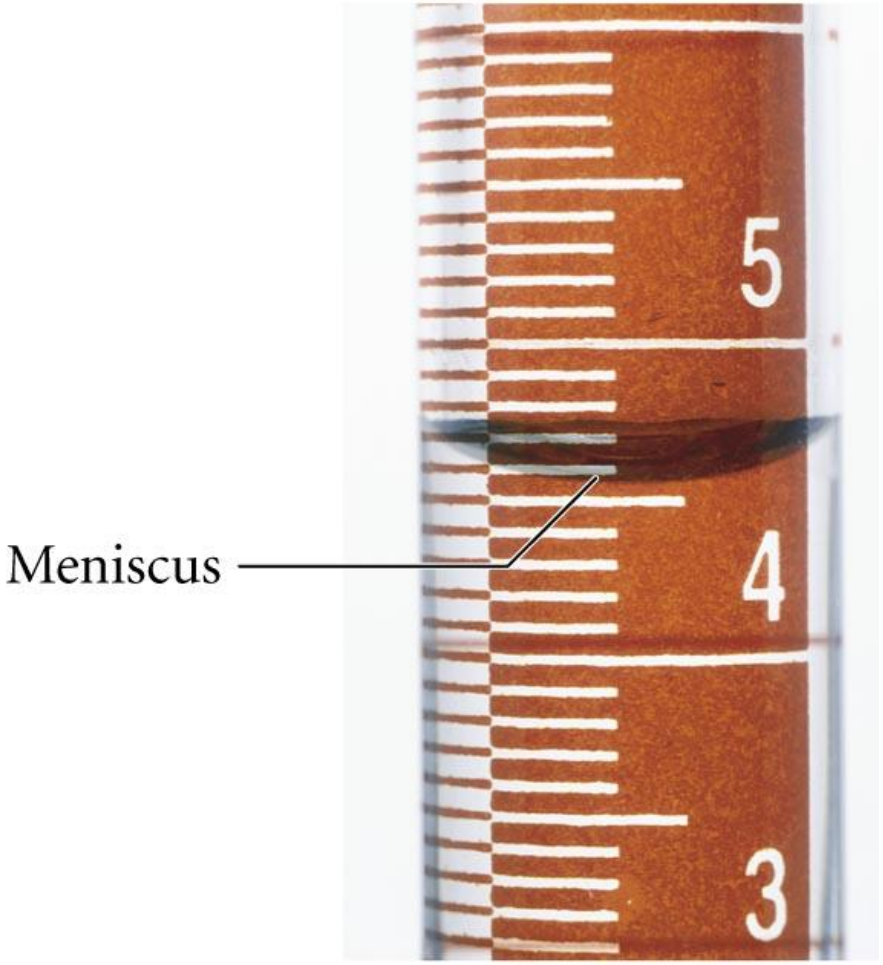
Measurement and Significant Figures

What Is a Measurement?

- Quantitative observation
- Comparison to an agreed standard
- Every measurement has a number and a unit



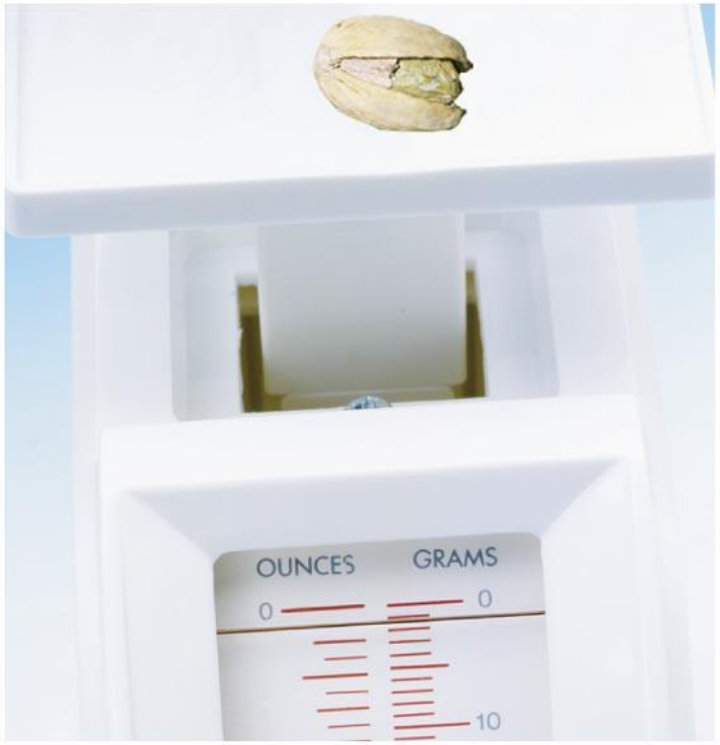
A Measurement

- 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



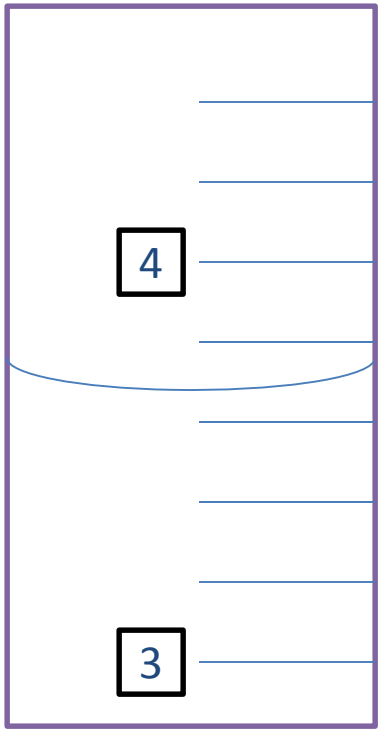
(a)

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