The Significance of Significant Figures

Significant Figures

- The Calculator does not tell you the answer
- There are 2 different types of numbers
  - Exact
  - Measured
- Exact numbers are infinitely important
- Measured number = they are measured and have ERROR.
- When you use your calculator your answer can only be as accurate as your worst measurement…. Why is science so hard

Exact Numbers

Counting objects are always exact

2 soccer balls

4 pizzas

Exact relationships, predefined values, not measured

1 foot = 12 inches

1 meter = 100 cm

For instance is 1 foot = 12.000000000001 inches? No

1 ft is EXACTLY 12 inches.

Learning Check

A. Exact numbers are obtained by
   1. using a measuring tool
   2. counting
   3. definition

B. Measured numbers are obtained by
   1. using a measuring tool
   2. counting
   3. definition

Solution

A. Exact numbers are obtained by

2. counting
3. definition

B. Measured numbers are obtained by

1. using a measuring tool

Learning Check

Classify each of the following as an exact or a measured number.

1 yard = 3 feet

The diameter of a red blood cell is 6×10^{-4} cm.

There are 6 hats on the shelf.

Gold melts at 1064°C.

Solution

Classify each of the following as an exact (1) or a measured(2) number.

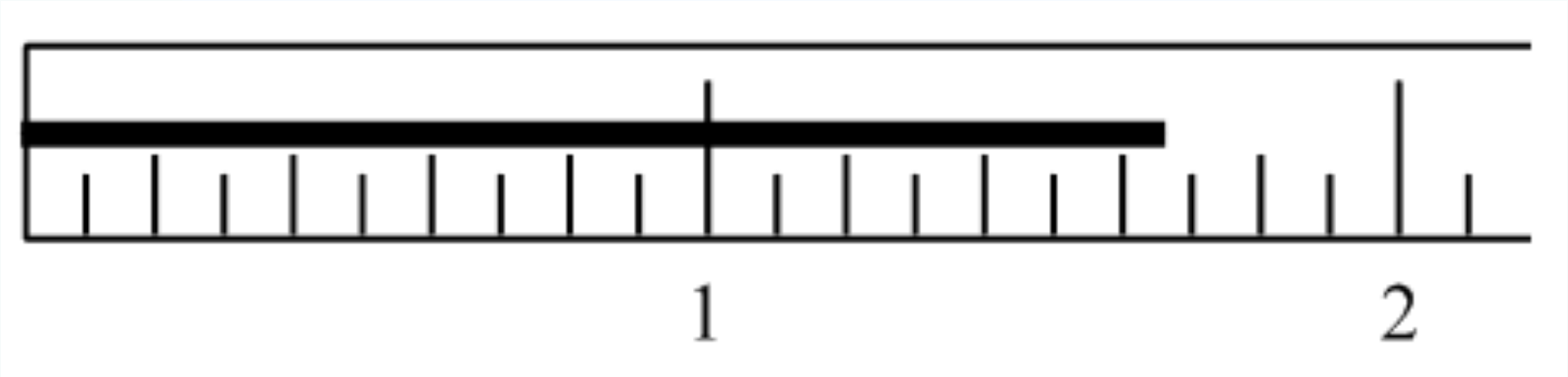
This is a defined relationship.

A measuring tool is used to determine length.

The number of hats is obtained by counting.

A measuring tool is required.

Using a ruler



- We can see the markings between 1.6-1.7cm
- We can't see the markings between the .6-.7
- We must guess between .6 & .7
- We record 1.67 cm as our measurement
- The last digit an 7 was our guess...stop there

Learning Check

What is the length of the wooden stick?

1) 4.5 cm
2) 4.54 cm
3) 4.547 cm

Measured Numbers

- Do you see why Measured Numbers have error…you have to make that Guess!
- All but one of the significant figures are known with certainty. The last significant figure is only the best possible estimate.
- To indicate the precision of a measurement, the value recorded should use all the digits known with certainty.

The 4 rules of zeros

When reading a measured value, all nonzero digits should be counted as significant.

- **RULE 1.** Zeros in the middle of a number are like any other digit; they are always significant.
  - 94.072 g
- **RULE 2.** Zeros at the beginning of a number are not significant; they act only to locate the decimal point.
  - 0.0834 cm
  - 0.029 07 mL

- **RULE 3.** Zeros at the end of a number and *after* the decimal point are significant.
  - 138.200 m
  - 138.2 m
- **RULE 4.** Zeros at the end of a number and *before* an implied decimal point may or may not be significant.
  - 0.489
  - 9380
  - 1290000

Practice Rule #1 Zeros

45.8736	•All digits count
.000239	•Leading 0's don't
.00023900	•Trailing 0's do
48000.	•0's count in decimal form
48000	•0's don't count w/o decimal
3.982×10^6	•All digits count
1.00040	•0's between digits count as well as trailing in decimal form

2.5 Scientific Notation

- **Scientific notation** is a convenient way to write a very small or a very large number.
- Numbers are written as a product of a number between 1 and 10, times the number 10 raised to power.
- 215 is written in scientific notation as:

$215 = 2.15 \times 100 = 2.15 \times (10 \times 10) = 2.15 \times 10^2$

$$215. = 2.15 \times 10^2$$

Decimal point is moved two places to the left, so exponent is 2.

$$0.002\,15 = 2.15 \times \frac{1}{1000} = 2.15 \times \frac{1}{10 \times 10 \times 10} = 2.15 \times \frac{1}{10^3} = 2.15 \times 10^{-3}$$

$$0.002\,15 = 2.15 \times 10^{-3}$$

Decimal point is moved three places to the right, so exponent is -3.

$$3.7962 \times 10^4 = 37{,}962$$

Positive exponent of 4, so decimal point is moved to the right four places.

$$1.56 \times 10^{-8} = 0.000\,000\,015\,6$$

Negative exponent of –8, so decimal point is moved to the left eight places.

2.6 Rounding Off Numbers

- Often when doing arithmetic on a calculator, the answer is displayed with more significant figures than are really justified.
- How do you decide how many digits to keep?
- 2 simple rules exist to tell you how.

- Once you decide how many digits to retain, the rules for rounding off numbers are straightforward:
- **RULE 1.** If the first digit you remove is 4 or less, drop it and all following digits.
  - Put 2.4271 into 2 significant figures.
- **RULE 2.** If the first digit removed is 5 or greater, round up by adding 1 to the last digit kept.
  - Put 4.5832 into 2 significant figures.

Practice Rule #2 Rounding

Make the following into a 3 Sig Fig number

1.5587	**1.56**
.0037421	**.00374**
1367	**1370**
128,522	**129,000**
1.6683×10^6	**1.67×10^6**

Your Final number must be of the same value as the number you started with, 129,000 and **not** 129

Examples of Rounding

For example you want a 4 Sig Fig number

4965.03	**4965**	0 is dropped, it is <5
780,582	**780,600**	8 is dropped, it is >5; Note you must include the 0's
1999.5	**2000.**	5 is dropped it is = 5; note you need a 4 Sig Fig

Rules for Multiplication and Division

RULE 1. In carrying out a multiplication or division, the answer cannot have more significant figures than either of the original numbers.

Three significant figures

Three significant figures

$$\frac{278 \text{ mi}}{11.70 \text{ gal}} = 23.8 \text{ mi/gal}$$

Four significant figures

Multiplication and division

$32.27 \times 1.54 = 49.6958$	**49.7**
$3.68 \div .07925 = 46.4353312$	**46.4**
$1.750 \times .0342000 = 0.05985$	**.05985**
$3.2650 \times 10^{6} \times 4.858 = 1.586137 \times 10^{7}$	**1.586×10^{7}**
$6.022 \times 10^{23} \times 1.661 \times 10^{-24} = 1.000000$	**1.000**