Measurement and significant figures

The Quality of Experimental Results

- Accuracy: how close a measured value is to the **actual (true) value**.
- Precision: how close the measured values are **to each other**.

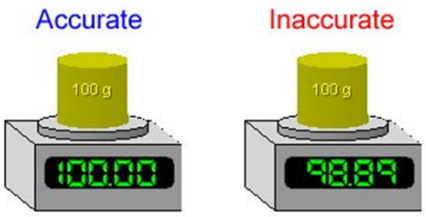
Precise but not accurate

Accurate but not precise

Accurate and precise

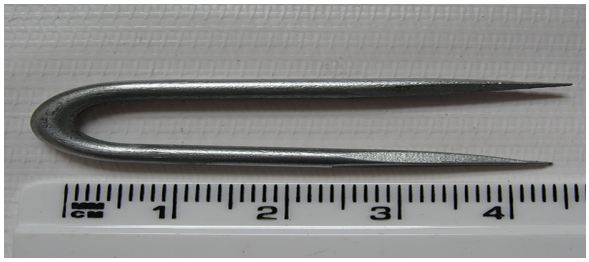
- Reliability: the consistency or repeatability of your measurement .
- Validity: how close your measurements are to the accepted value.
  - For example:

  You are given a 100g weight to mass on an electronic balance.
  If your scale were to repeatedly measure 98.89 g we could say that it is very precise (results are reliable) , but not very accurate (results are not valid).
  Instrumental error often occurs with equipment.!!



Reading measuring instruments to their limit

- You can only be as precise as your measuring instrument allows you to be.
- Ex.



> This object measures 4.40 cm (last digit is uncertain)
> You might say 4.39 or 4.41, but you cannot add any more decimal places

- How much fluid is in this graduated cylinder?

What is the temperature?

- Sig figs help us understand how precise measurements are
- Using sig figs increases accuracy and precision
- Sig figs cut down on error caused by improper rounding

HOORAY FOR SIG FIGS!!!

Which digits are significant?

- Rule #1: All non-zero digits are significant.
  - 24 has two sig figs, 24.1 has 3 sig figs

- Rule #2: All zeros bounded by non-zero integers are significant.
  - 2004 has four sig figs 20.04 also has 4 sig figs

- Rule #3: Zeros placed before other digits (leading zeros) are not significant.
  - 0.024 has 2 sig figs

- Rule #4: Zeros at the end of a number are significant ONLY if they come after a decimal point.
  - 2.40 has three sig figs 240 only has 2 sig figs

Practice:

- How many sig figs?

409.25	0.050	0.003500
83	300 900	0.916
98.207	4.67×10^{-7}	0.200
0.001	45.030	5 234 000
4.3×10^{2}	35 000	150 000 001
0.003050	0.004400	460 090
4 200	16.8090	50.00300

Rules for Addition and Subtraction

- Answers must be rounded to the **same decimal place** (not sig figs) as the **least** number of decimal places in any of the numbers being added or subtracted.

  - Ex. 2.42 + 14.2 + 0.664 = 17.2842 becomes

  If there is no decimal point in one of the numbers, all decimal points are dropped.

Ex 1- 6.25 + 4.350 + 15.809 = 26.409
becomes

Ex 2- 14.4 + 12.0 - 5 = 21.4
becomes

Ex 3- 589.090 + 0.04 + 78.890 = 668.02
becomes

Ex 4- 33.2306 + 5.050 + 0.00604 = 38.28664
becomes

Rules for Multiplication and Division

- The number of sig figs in the answer should be the same as in the number with the least sig figs being multiplied or divided.
  - Ex. 7.3 x 1264 = 9227.2 becomes= 9200 9.2×10^3

Ex 1- 15.0 x 4.515 x 1376 = 931 896
becomes 932 000 or 9.32×10^5

Ex 2- 0.003 x 0.050 x 0.04 = 0.000006
becomes 6×10^{-6}

Ex 3- 45.56 x 134.04 x 0.340 = 2076.333216
becomes 2080 2.08×10^3

Ex 4- 34.56 x 14 x 134.020 = 64844.2368
becomes 65000 6.5×10^4

When doing multiple steps in a word problem

- Solve each step using order of operations.
- Do not round off any number.
- Once you have your final answer, then you use significant figures according to the last step you do.

Ex: $\frac{125 \times 345.5}{65.3 + 16.6} = \frac{43187.5}{81.9} = 527.3199023$

This becomes 527

Exceptions and special circumstances

(Just like French verbs)

1. Adding and scientific notation

$$\frac{(5.8 \times 10^2) + 368}{4.87 \times 10^5}$$

- When adding and using SN, the exponents must be the same.

You have 2 options to solve the problem.

1- Convert 5.8 x10^2 to 580 and get rid of the exponent

580 + 368

2- Convert 368 to the same exponent so it becomes 3.68 x 10^2

5.8 x 10^2 + 3.68 x 10^2

Both are correct, but option 1 is easier

2. Rounding off and keeping a zero as a significant digit

$$\frac{8253.0569}{12.7} = 649.847$$

- In this example you must keep 3 sig figs in your answer.

When rounding off 649.847 should become 650.

Problem, 650 only has 2 sig figs
Solution: put a – above the zero, this makes it significant.
Becomes $6\bar{5}0$ 6.50×10^2

3. Having many insignificant zero's and addition

- When adding the following: 136.2 + 2 500 000 + 14.01

We get 2 500 150.21 which should become 2 500 150.

EXCEPT, we have to use sig figs, and the addition rule says that we must round to the least precise decimal place.
Therefore, because 2 500 000 is only precise to the hundred thousands place, we need to round the answer to 2 500 000.

- **You cannot be more precise than your least most precise number.**

This is true for any additions that end in non sig. zero's. ex-
5 500 + 15 = 55 15 but becomes
310 + 6 = 316 but becomes
259 500 + 1670 + 23 = 261 193 but becomes

4. Converting units

- When converting units, sig figs need to be maintained.

Ex 1- 4.0 cm to m becomes 0.040 m not 0.04 m
Ex 2- 1250 mL becomes 1.25 L not 1.250 L

5. Constants

- When there is a constant in a formula, the constant does not count as a significant figure.

ex: Coulomb's constant 9×10^9 Nm^2/C^2

SIG FIGS

1. How many sig figs are in each of the following numbers?

a) 0.09304 4
b) 6.58×10^7 3
c) 0.0200 3
d) 0.10101 5
e) 4.508 4
f) 1204.0 5
g) 2.9×10^{-3} 2
h) 2.4×10^7 2
I) 460 2
J) 23.230 5

2. Solve using the correct number of significant figures.

a- 13.5 x 14.2 x 13.080 x 0.01=

25.07436 = 30

b- 187 x 0.008 ÷ 14.2887 =

0.104698118 = 0.1

c- 911 x 677 x 0.0089 =

5489.0483 = 5500 5.5×10^3

d- $8.0 \times 10^5 \div 4.02 \times 10^9$ =

0.000199005 = 2.0×10^{-4} 0.00020

e- $(1.23 \times 10^5)\ (1.445 \times 10^7) \div 0.023$ =

$7.727608696 \times 10^{13}$ = 7.7×10^{13}

Psych-

Why would I want to correct 54 essays on significant figures?????