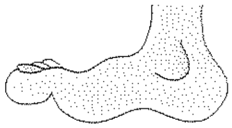
Significant Digits and Isotopic Abundance



How big?

How small?

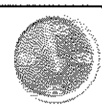
How accurate?

Scientific notation

- Read "Scientific Notation" on page 621
- Complete the chart below

Decimal notation	Scientific notation
127	
0.0907	
	5.06×10^{-4}
	2.3×10^{12}

What time is it?



- Someone might say "1:30" or "1:28" or "1:27:55"
- Each is appropriate for a different situation
- In science we describe a value as having a certain number of "significant digits"
- The # of significant digits in a value includes all digits that are certain and one that is uncertain
- "1:30" likely has 2, 1:28 has 3, 1:27:55 has 5
- There are rules that dictate the # of significant digits in a value (read handout up to A. Try A.)

Significant Digits

- It is better to represent 100 as 1.00×10^2
- Alternatively you can underline the position of the last significant digit. E.g. $10\underline{0}$.
- This is especially useful when doing a long calculation or for recording experimental results
- Don't round your answer until the last step in a calculation.
- Note that a line overtop of a number indicates that it repeats indefinitely. E.g. $9.\overline{6} = 9.6666\ldots$
- Similarly, $6.\overline{54} = 6.545454\ldots$

Adding with Significant Digits

- How far is it from Toronto to room 229? To 225?
- Adding a value that is much smaller than the last sig. digit of another value is irrelevant
- When adding or subtracting, the # of sig. digits is determined by the sig. digit furthest to the left when #s are aligned according to their decimal.
- E.g. a) 13.64 + 0.075 + 67 b) 267.8 – 9.36

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  13.64
+  0.075        267.8
+ 67.          − 9.36
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  81            258.4
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- Try question B on the handout

Multiplication and Division

- Determining sig. digits for questions involving multiplication and division is slightly different
- For these problems, your answer will have the same number of significant digits as the value with the fewest number of significant digits.
- E.g. a) 608.3 x 3.45 b) 4.8 ÷ 392

a) 3.45 has 3 sig. digits, so the answer will as well
$608.3 \times 3.45 = 20\underline{9}8.635 = 2.10 \times 10^3$

b) 4.8 has 2 sig. digits, so the answer will as well
$4.8 \div 392 = 0.01\underline{2}245 = 0.012$ or 1.2×10^{-2}

- Try question C and D on the handout (recall: for long questions, don't round until the end)

Unit conversions

- Sometimes it is more convenient to express a value in different units.
- When units change, basically the number of significant digits does not.

E.g. 1.23 m = 123 cm = $12\underline{3}0$ mm = 0.00123 km

- Notice that these all have 3 significant digits
- This should make sense mathematically since you are multiplying or dividing by a term that has an infinite number of significant digits

E.g. $12\underline{3}$ cm x 10 mm / cm = $12\underline{3}0$ mm

- Try question E on the handout

Isotopic abundance

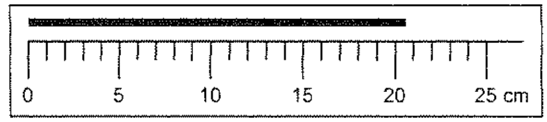
- Read 163 – 165
- Let's consider the following question: if ^{12}C makes up 98.89% of C, and ^{13}C is 1.11%, calculate the average atomic mass of C:

Mass from ^{12}C atoms	+	Mass from ^{13}C atoms	
12 x 0.9889	+	13 x 0.0111	
$11.8\underline{6}68$	+	$0.14\underline{4}3$	= 12.01

- To quickly check your work, ensure that the final mass fits between the masses of the 2 isotopes

SIGNIFICANT DIGITS

Summary: associated with every measurement made is some degree of uncertainty. For instance, you might measure the length of the dark line shown in the diagram as 20.7 cm. The digits 2 and 0 are certain - there is no doubt that the length is "20 point something" cm. The 7 is uncertain - it might be a little less or a little more. The number of 'significant digits' indicates the certainty of our measurement. There are three significant digits in this case (20.7). Thus, significant digits in a measurement or calculation consist of all those digits that are certain, plus one uncertain digit. Although your calculator may give you an answer to eight decimal places or more, you should not include all of these digits in your answer.



The length of the line is approx. 20.7 cm.
The 2 and 0 are certain, the 7 is uncertain.
All three digits are significant.

Rules For Determining The Number Of Significant Digits

If you have trouble determining the number of significant digits, follow these steps.

1. All digits from 1 to 9 (non-zero digits) are considered to be significant.

Example	Number of significant digits
1.23 g	3

2. Zeros between non-zero digits are always significant

1.03 g	3

3. Zeros to the left of non zero digits, serve only to locate the decimal point; they are not significant.

0.00123 g	3; zeros to the left of the 1 simply locate the decimal point. To avoid confusion you can write numbers in scientific notation. I.e. $0.00123 = 1.23 \times 10^{-3}$

4. Any zero printed to the right of a non-zero digit is significant if it is also to the right of the decimal point.

2.0 g and 0.020 g	2 for both; all zeros that are right of both a non-zero digit and the decimal point are significant.

5. Any zero printed to the right of a non-zero digit may or may not be significant if there is no decimal point indicated. For example, if someone tells you that a mountain is 3600 m high they are probably certain of the 3, and uncertain of the 6. In other words, there are likely 2 significant digits. However 3600 m may also have 3 significant digits (if the measurement was taken to the nearest 10 m) or 4 significant digits if the measurement was taken to the nearest 1 m).

100 g	1, 2, or 3; in numbers that do not contain a decimal point, "trailing" zeros may or may not be significant. To eliminate possible confusion, one practice is to underline the last significant digit. Thus, 1$\underline{0}$0 has two significant digits, whereas 10$\underline{0}$ has three. Ideally, we write the number in scientific notation: for example 1.0×10^{-2} has two significant digits and 1.00×10^{-2} has three significant digits. Notice that for numbers written in scientific notation, all digits are significant.

6. Any number that is counted instead of measured has an infinite number of significant digits.

3 test tubes	Infinite; exact numbers, for example, the number of meters in a kilometer or numbers obtained by counting (4 people, 5 beakers), are said to have an infinite number of significant digits.

A) How many significant digits do the following measured quantities have?

i) 2.83 cm	iii) 14.0 g	v) 0.02 mL	vii) 2.350×10^{-2} L	ix) 3 fingers
ii) 36.77 mm	iv) 0.0033 kg	vi) 0.2410 km	viii) 1.00009 L	x) 0.0056040 g

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B) i) 83.25 – 0.1075 ii) 4.02 + 0.001 iii) 0.2983 + 1.52

C) i) 7.255 ÷ 81.334 ii) 1.142 x 0.002 iii) 31.22 x 9.8

D) Solve the following (do one step at a time, according to BEDMAS): i) 6.12 x 3.734 + 16.1 ÷ 2.3
ii) 0.0030 + 0.02 iii) $1.70 \times 10^{3} + 1.34 \times 10^{5}$ iv) (33.4 + 112.7 + 0.032)/(6.487)

E) Convert these measurements: i) 1.0 cm = ______ m, ii) 0.0390 kg = ______ g, iii) 1.7 m = _____ mm