Measured Values and Significant Figures

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- Goals:
- Metric prefixes (k, c, m)
- Exponential notation ($N \bullet 10^x$)
- Handling "uncertainty in numbers"
- Significant Figures
- Measurements 1 in =__cm; 1qt = __L; 1lb =__ g
- Dimensional Analysis

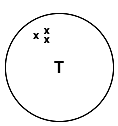
….and <u>measurements</u> will have to be made!!!!

Measurements - a system or way of gathering numerical values—size, extent, quantity, dimension–using a measuring device.

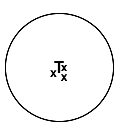
A. Accuracy: the degree to which a measured value is close to the true value.

B. Precision: the degree to which a "set" of measured values agree with each other.

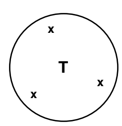
Compare the weigthed average of the "x's" to the value " T" which represents the true value. Decide which of the measurement is accurate, precise, both accurate and precise or neither.



<u>precise</u> but inaccurate



<u>precise</u> & <u>accurate</u>



inaccurate but by chance; the result of the average of the three x's will be accurate

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A. Metric Prefixes

PREFIX	SYMBOL	DECIMAL EQUIVALENT	POWER OF BASE 10
mega			
kilo	k	1000	10^3 or E 3
deci			
centi	c	0.01	c = ???
milli	m	0.001	10^{-3} or E -3
micro			
nano			

definitely memorize these

$10 = 10^1 = E\ 1$

$10^1 \bullet 10^1 \bullet 10^1 = 1000 = E\ 3$

$\frac{1}{10^1} \bullet \frac{1}{10^1} \bullet \frac{1}{10^1} = \frac{1}{1000} = 0.001 = E\ {-3}$

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B. Scientific (Exponential)

- Notation Form - a short hand device used for expressing very large numbers or very small numbers. Extra help is usually given in the back of your book in the appendix

$N \times 10^X$

N = a number between 1 and 10

8069 using scientific (exponential) notation
8069 can be written as 8.069×10^3 or 8.069 E 3

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A closer look at moving the decimal point

8069 can be written as 8.069×10^3 or 8.069 E 3

Moving the decimal to the left affords a positive E value

806.9×10^1	806.9 E 1
80.69×10^2	80.69 E 2
8.069×10^3	8.069 E 3

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C. Multiplication of Exponents

- $(M \times 10^m)(N \times 10^n) = (MN) \times 10^{m+n}$
- $(5 \times 10^5)(9 \times 10^8) = (5)\bullet(9) \times 10^{5+8}$

  $= 45 \times 10^{13}$ or 4.5×10^{14}
- $(5 \times 10^5)(9 \times 10^{-8}) = (5)\bullet(9) \times 10^{5-8}$

  $= 45 \times 10^{-3}$ or 4.5×10^{-2}

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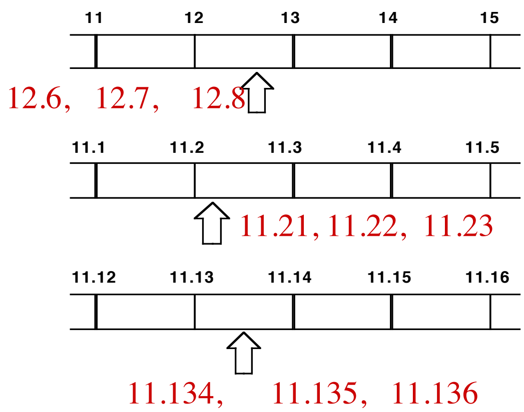
C. Measured Values And Significant Figures:



reading = 12.7 ± 0.1
least reliable scale
highest uncertainty

reading = 11.22 ± 0.01
more reliable scale
lower uncertainty

reading = 11.135 ± 0.001
most reliable scale
least uncertainty

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How then do we go about citing degree of confidence in a measurement?

We will do this by describing measurements in terms of significant figures.

Thus we will need to memorize the rules for significant figures.

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Rules of Counting Significant Figures

8069 has a total of <u>four</u> significant figures

1. ALL non-zero digits in a number are significant.

   8069 8, 6, 9 are significant

2. Captive zeros - zeros located between nonzero digits are significant.

   8069 0 is significant

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   there are none

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   there are none

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Rules of Counting Significant Figures

2.54 has a total of <u>three</u> significant figures

1. ALL non-zero digits in a number are significant.

   2.54 the 2, 5, 4 are significant

2. Captive zeros - zeros located between nonzero digits are significant.

   there are none

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   there are none

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   there are none

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Rules of Counting Significant Figures

10.21 has a total of four significant figures

1. ALL non-zero digits in a number are significant.

   10.21 1, 2, 1 are significant

2. Captive zeros - zeros located between nonzero digits are significant.

   10.21 0 is significant

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   there are none

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   there are none

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Rules of Counting Significant Figures

1000.0 has a total of five significant figures

1. ALL non-zero digits in a number are significant.

   1000.0 the 1 is significant

2. Captive zeros - zeros located between nonzero digits are significant.

   there are none

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   1000.0 the 0 after decimal is significant

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   None

   BUT, at this point consider rule 3 again

The three zeros between the decimal and the 1 are significant

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Rules of Counting Significant Figures

10000 has a total of one significant figures

1. ALL non-zero digits in a number are significant.

   10000 the 1 is significant

2. Captive zeros - zeros located between nonzero digits are significant.

   there are none

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   None; the number doesn't have a decimal pt

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   None

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Rules of Counting Significant Figures

8.00×10^{-3} has a total of three significant figures

1. ALL non-zero digits in a number are significant.

   8.00×10^{-3} the 8 is significant

2. Captive zeros - zeros located between nonzero digits are significant.

   there are none

3. Trailing zeros - zero at the end of a number having a decimal point are significant

   the two 0's after the decimal are significant

4. Leading zeros - zeros that serve only to locate the position of the decimal point. Place holder preceding are NOT significant.

   None

Rules of Counting Significant Figures

1 is definitely exact — 1 ft = 12 in — 12 is exact as defined by this equivalence statement

1 in = 2.54 cm

These are **exact numbers**. Exact numbers are not limited to a given number of sig figs.

Exact numbers have an infinite number of significant figures

12.000000000000000000000000000000000000000000

1.0000000000000000000000000000000000000000000

Let's Check Our Work

	# of Sig Figs	exponential notation	round off to 3 sig figs
a. 800003	6	8.00003×10^{5}	8.00×10^{5}
b. 1.21	3	1.21×10^{0}	1.21×10^{0}
c. 149700 "assume"	4	1.497×10^{5}	1.50×10^{5}
d. 14.000	5	1.4000×10^{1}	1.40×10^{1}
e. 0.03995	4	3.995×10^{-2}	4.00×10^{-2}
f. 9.999×10^{3}	4	9.999×10^{3}	$10.0 \times 10^{3} = 1.00 \times 10^{4}$

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Let's Check Our Work

HUH????

measurement	exponential notation	fundamental unit	# of Sig Figs
a. 7070.0 mg	7.0700×10^{3} mg	7.0700 g	5
b. 10.21 nm	1.021×10^{1} nm	1.021×10^{-8} m	4
c. 1497.00 ds	1.49700×10^{3} ds	1.49700×10^{2} s	6
d. 14.000 cL	1.4000×10^{1} cL	1.4000×10^{-1} L	5
e. 0.03995 μL	3.995×10^{-2} μL	3.995×10^{-8} L	4
f. 0.0009999 Mg	9.999×10^{-4} Mg	9.999×10^{2} g	4

add this to your note

Conversion to the fundamental unit

7.0700×10^{3} mg = 7.0700 g

m = 10^{-3} substitute m for 10^{-3}

$7.0700 \times 10^{3} \times 10^{-3}$ g = 7.0700 g

add exponents together

1.021×10^{1} nm = 1.021×10^{-8} m

n = 10^{-9} substitute n for 10^{-9}

$1.021 \times 10^{1} \times 10^{-9}$ m = 1.021×10^{-8} m

add exponents together

Handling Sig Figs when doing math

When multiplying or dividing, the number of significant figures in the result cannot exceed the least known number of significant figures in the problem.

a. 1.05×10^{-3} (3sf) ÷ 5.263×10^{-5} (4sf) = 2.00×10^{1} (3sf)

1.00×10^{3} (3sf) × 9.9×10^{-3} (2sf) = 9.9 (2sf)

b. 3.77 ft (3sf) × 12 inches / 1 ft (exact) = 4.52×10^{1} (3sf)

1.00×10^{3} (3sf) ÷ 9.9×10^{-3} (2sf) = 1.0×10^{5} (2sf)

c. 483.21 (5sf) × 5.00 (3sf) = 2.42×10^{3} (3sf)

d. 0.002 (1sf) / 0.041 (2sf) = 5×10^{-2} (1sf)

Handling Sig Figs when doing math

For addition and substraction, the final answer should be rounded off to the first "common place"

g
```
   0.93  ← 2sf
+ 10.1   ← 3sf common place
  11.0   ← 1sf past decimal
```
or 1.10×10^{1}

h
```
  16.43  ← 4sf
-  2.1   ← 2sf common place
  14.3   ← 1sf past decimal
```
or 1.43×10^{1}

i
```
  121.12  ← 5sf
   18.0   ← 3sf com p
+   1.013 ← 4sf
  140.1   ← 1sf past decima
```
or 1.401×10^{2}

For addition and substration - the limiting term in the measurement will be the **smallest number of digits past the decimal place**

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H. Calculating a Percentage Error

Scientists check the accuracy of their measurements by comparing their results with values that are well established and are considered "accepted values"

$$\text{percent error} = \frac{|y - x|}{y}(100\%) =$$

x: your value

y is actual value

What is the percentage error of the density if the experimental value is 1.36 g/mL and the accepted value is 1.32 g/mL? (ANS: 3 % error)

$$\text{percent error} = \frac{|1.32 - 1.36|}{1.32}(100\%) = \frac{|-0.04|}{1.32} \times (100\%) = 3\%$$

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Factor Label Method

The basic idea is that multiplying a quantity times a fraction (or several fractions) that equal one does not change the value of the quantity but may change the units that express the quantity.

Based on the following mathematical principles:

1. Multiplying any quantity by 1 does not change its value:

4 cents x 1 = 4 cents   3 cm x 1 = 3 cm

2. Dividing any quantity by itself is equal to 1.

$$\frac{4}{4} = 1 \qquad \frac{3\text{ apples}}{3\text{ apples}} = 1 \qquad \frac{Z\text{ cm}}{Z\text{ cm}} = 1$$

3. Any two quantities that are equal to one another, when made into a fraction give 1.

$4 = 4 \therefore 4/4 = 1$ $1\text{ foot} = 12\text{ inches} \therefore \frac{1\text{ foot}}{12\text{ inches}} = 1$ and $\frac{12\text{ inches}}{1\text{ foot}} = 1$

supplemental HO 21

Writing metric equivalent statements:

1. Always make the metric prefix equal to the numerical value of the fundamental unit:

$1\ kg = 10^{3}\ g$ $1\ mg = 10^{-3}\ g$

2. The above equivalent statements can lead to either of two conversion factors:

$\frac{1\ kg}{10^{3}\ g}$ or $\frac{10^{3}\ g}{1\ kg}$ $\frac{1\ mg}{10^{-3}\ g}$ or $\frac{10^{-3}\ g}{1\ mg}$

3. Which conversion factor shall we use? The one that cancels the unwanted labels (units) and gives the desired label.

Example: Convert 50 grams to milligrams: x kg = 50 g

$x\ kg = 50\ g \times \frac{1\ kg}{10^{3}\ g} = 5 \times 10^{-2}\ kg$ NOT $x\ kg = 50\ g \times \frac{10^{3}\ g}{1\ kg} = 5 \times 10^{4}\ \frac{g^{2}}{1\ kg}$

supplemental HO 22

Charlie Brown Handout

- Applying sigfigs and metric conversion

CARTOON CORNER

Discussion questions

1. The referee is really upset with the metric system. What length of race was he anticipating?

2. Complete the equivalent statement 1 mile = 1.6093 kilometers

3. a. What is the distance of a 10-K run in miles?
   b. What is this distance in feet?

$10.\ km \times \frac{1\ mile}{1.6093\ km} = 6.2\ miles$

4. If a runner is capable of running a five minute mile,
   a. how many miles can he travel in one hour?
   b. What is this speed in kilometers per hour?

$\frac{1\ mile}{5\ min} \times \frac{60\ min}{1\ hour} = \frac{12\ miles}{1\ hour} \times \frac{1.6093\ km}{1\ mile} = 19\ km$

IN THE BLEACHERS By Steve Moore

"Wait, wait!! We might have a problem here . . . blast this metric system!"

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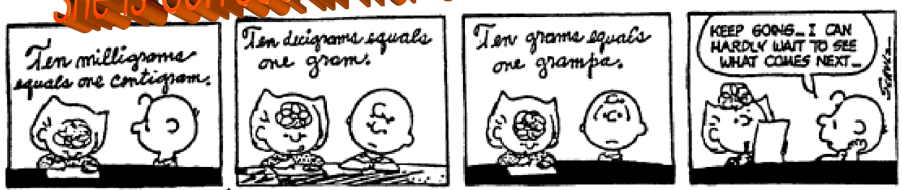
Sally and Charlie

She is Correct in her statements!!!



6. Sally is diligently working on her metric conversions.
Would you agree or disagree with her above statements:

a. "Ten milligrams equals one centigram"	b. "Ten decigrams equals one gram"
10 mg = 1 cg	10 dg = 1 g
$10 \cdot 10^{-3}$ g = $1 \cdot 10^{-2}$ g	$10 \cdot 10^{-1}$ g = 1 g

m = 10^{-3} substitute m for 10^{-3} d = 10^{-1} substitute d for 10^{-1}

c = 10^{-2} substitute c for 10^{-2}

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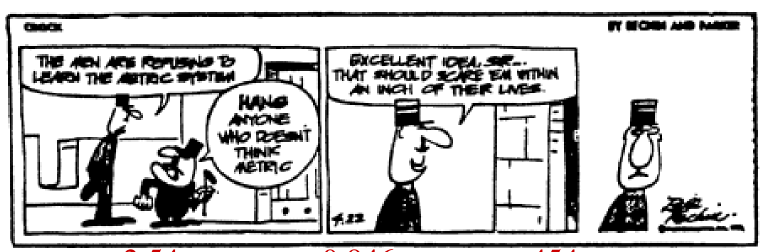
Think Metric…or Else!



8. Complete 1 inch = 2.54 cm; 1 qt = 0.946 L; 1 lbs = 454 g (MEMORIZE THESE)

Memorize these equivalent statements for English to Metric conversions

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Conversions

1. How many centimeters is equal to 45.7 mm? We could write this mathematically as, ????? cm = 45.7 mm

We begin by writing down what we know.
We know that 1 mm = 10^{-3} m and 1 cm = 10^{-2} m.

1 mm = 10^{-3} m
1 cm = 10^{-2} m

factor labels

Arrange the factor-label labels so units will cancel.

$$???? \text{ cm} = 45.7 \text{ mm} \times \frac{10^{-3} \text{ m}}{1 \text{ mm}} \times \frac{1 \text{ cm}}{10^{-2} \text{ m}} = 4.57 \text{ cm}$$

(7.0700 x E3) x Emeasurement exponential notation fundamental u

a. 7070.0 mg 7.0700 x 10^{3} mg 7.0700 g 5

b. 10.21 nm 1.021 x 10^{1} nm 1.021 x 10^{-8} m 4

c. 1497.00 ds 1.49700 x 10^{3} ds 1.49700 x 10^{2} s 6

d. 14.000 cL 1.4000 x 10^{1} cL 1.4000 x 10^{-1} L 5

e. 0.03995 mL 3.995 x 10^{-2} mL 3.995 x 10^{-8} L 4

f. 0.0009999 Mg 9.999 x 10^{-4} Mg 9.999 x 10^{2} g 4

-3 =

$$7.0700 \times 10^{3}\ \text{mg} = 7.0700\ \text{g}$$

$$7.0700 \times 10^{3} \times 10^{-3} = 7.0700\ \text{g}$$