9:10AM – 12:20PM

Lab Experiment: Exercise A – Math Drill

CHEM 110L – GLENDALE COLLEGE

http://themalloryfamily.net

1

Things you should have…

- Goggles (splash proof)
- Lab Manual
- Calculator
- Partner

Things you should **NOT** have…

- Food
- Drinks (yes even water)
- Open toe shoes
- Dangling clothing

http://themalloryfamily.net

2

LAB PARTNERS

- Know their name!!!
- Know their email address!!!
- Know their text number!!!
- Know their phone number!!!
- Know their backup email address!!!
- Know their bank pin number… *oops, not this*

3

Goggles????

http://themalloryfamily.net

4

New Stuff!

To begin let's try to understand two words…

Precision

Accuracy

http://themalloryfamily.net

5

Precision

Full Definition of PRECISION

1 : the quality or state of being **precise** : EXACTNESS

2 **a :** the degree of refinement with which an operation is performed or a measurement stated — compare ACCURACY 2b

b : the accuracy (as in binary or decimal places) with which a number can be represented usually expressed in terms of the number of computer words available for representation <double *precision* arithmetic permits the representation of an expression by two computer words>

3 : RELEVANCE 2

—pre·ci·sion·ist \-ˈsi-zhə-nist, -ˈsizh-nist\ *noun*

http://themalloryfamily.net

6

Accuracy

Full Definition of ACCURACY

plural **ac·cu·ra·cies**

1 : freedom from mistake or error : CORRECTNESS

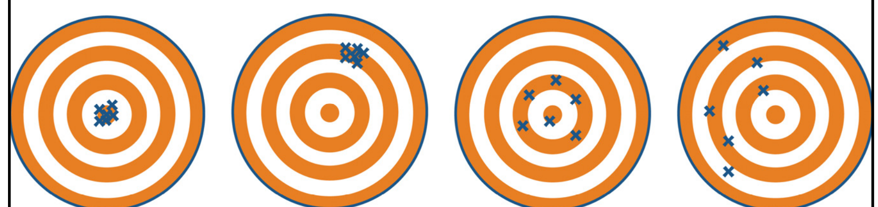
2 **a :** conformity to truth or to a standard or model : EXACTNESS

b : degree of conformity of a measure to a standard or a true value — compare PRECISION 2a

http://themalloryfamily.net

7

Precision vs Accuracy



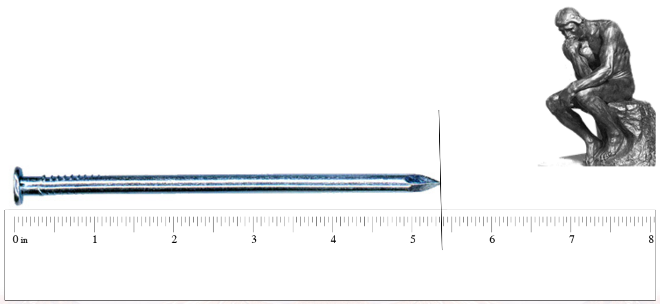
High Accuracy High Precision | **Low Accuracy High Precision** | **High Accuracy Low Precision** | **Low Accuracy Low Precision**

http://themalloryfamily.net

8

SIGNIFICANT FIGURES

How long is the nail?



Graduated Cylinder Meniscus

SIGNIFICANT FIGURE RULES

	Example	Sig. Digits	Sci-Notation
1 All non-zero digits are significant			
	1.589	4	1.589E+00
	0.897	3	8.97E-01
	36000	2	3.6E+04
2 Significant Zero's			
a All sandwiched zero's	13.02	4	1.302E+01
	1.0002	5	1.0002E+00
	10.5	3	1.05E+01
b All trailing zero's preceded by a digit to the right of the decimal point.	5.000	4	5.000E+00
	20.000	5	2.00000E+01
	15.00	4	1.500E+01
3 Non significant Zero's			
a Leading Zeros	0.0200	3	2.00E-02
	0067	2	6.7E+01
b Trailing Zero's to the left of the decimal point in a number without a decimal point	56000	2	5.6E+04
	1360	3	1.36E+03

*NOTE: Write the numbers in exponential notation if you have any doubt. All zeros used to indicate the power of 10 (order of magnitude) are not significant.

Significant Figure Rules

- Remember…
  - The last digit you are not sure of.
  - All non-zero digits are significant
  - All leading zeros are insignificant
  - All sandwiched zeros are significant
  - Trailing zeros
    - To the right of the decimal point are significant
    - To the left of the decimal point are insignificant
- Do some examples…
- Next… Rounding significant digits…

SIGNIFICANT FIGURES

Rounding Off

1 If the last digit to be retained in a number is followed by a number less than 5 (<5), **ROUND DOWN.**

Round to 3 significant figures:

28.23	rounds to	28.2
578.1	rounds to	578

2 If the last digit to be retained in a number is followed by a number greater than 5 (>5), **ROUND UP.**

Round to 2 significant figures:

5.998	rounds to	6.0
0.00258	rounds to	0.0026
3.6502	rounds to	3.7

3 If the last digit to be retained in a number is followed by 5 (0000000… implied), **ROUND** the last digit retained to an **EVEN NUMBER.**

Round to 2 significant figures:

1.75	rounds to	1.8
1.050	rounds to	1.0
1.45	rounds to	1.4

Round to 4 significant figures:

67.835	rounds to	67.84
67.885	rounds to	67.88

13

Examples

12.6 to two significant digits
12.5 to two significant digits
13.5 to two significant digits
12.5001 to two significant digits
11.5001 to two significant digits
1000 to two significant digits

14

Systems of Units

- Two major systems of units
- British (English) system – only used widely in the United States (miles, inches, pounds, seconds, etc.)
- Metric system – used throughout most of the world (kilometers, meters, grams, etc.)
- The U.S. “officially” adopted the metric system in 1893, but continues to use the British system.

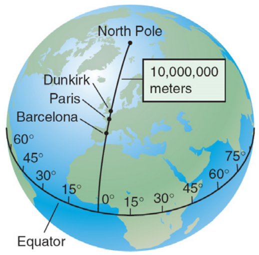
15

Length

- *The measurement of space in any direction*
- Space has three dimensions – length, width, and height.
- Metric Standard Unit = Meter (m), originally defined as 1/10,000,000 of distance from equator to north pole
- British Standard Unit = Foot, originally referenced to the human foot.

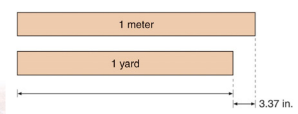
16

The Meter



Originally defined as a physical quantity of nature.

1/10,000,000 of the distance from the equator to the pole.



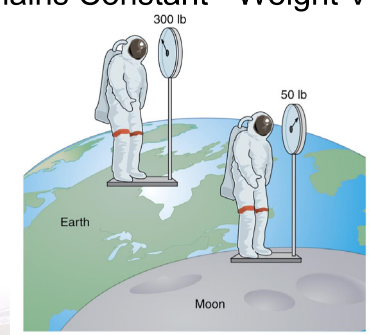
Mass (metric)

- *The amount of matter an object contains*
- An object's mass is always constant
- Mass is a fundamental unit that will remain constant throughout the universe.
- <u>Metric Standard Unit</u> = <u>Kilogram</u> (kg) – originally defined as the amount of water in a 0.1m cube. Now referenced to a cylinder in Paris

Mass (British)

- <u>British Standard Unit</u> = Slug (rarely used)
- We use the <u>Pound</u> (lb.)
- The pound is actually not a unit of mass, but rather of weight, related to gravitational attraction (depends on where the object is!)
- Object: Earth = 1lb. ➔ Moon = 1/6lb.
- In fact, the weight of an object will vary slightly depending on where it is on earth (higher altitude→ less weight)

Mass is a Fundamental Quantity and Remains Constant - Weight Varies



Units
- Length: Meter
- Mass: Kilogram
- Time: Second

Time

- Time - the continuous, forward flowing of events
- Time has only one direction → forward
- Second (s) – the standard unit in both the metric and British systems
- Originally 1/86,400 of a solar day
- Now based on the vibration of the Cs^{133} atom (Atomic Clock)

21

Units
- Length: Meter
- Mass: Kilogram
- Time: Second

Modern Metric System (SI)

- The fundamental units are a choice of seven well-defined units which by convention are regarded as dimensionally independent:
  - meter, m (length)
  - kilogram, kg (mass)
  - second, s (time)
  - ampere, A (electrical current)
  - kelvin, K (temperature)
  - mole, mol (amount of a substance)

22

Powers-of-10 Notation (Scientific Notation)

- Many numbers are very large or very small – it is more convenient to express them in 'powers-of-10' notation
- $1{,}000{,}000 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^6$

$$\frac{1}{1{,}000{,}000} = \frac{1}{10^6} = \mathbf{0.000001 = 10^{-6}}$$

23

Scientific Notation

- The distance to the sun can be expressed many ways:
  - 93,000,000 miles
  - 93×10^6 miles
  - 9.3×10^7 miles
  - 0.93×10^8 miles
- All four are correct, but 9.3×10^7 miles is the preferred format.

24

Rules for Scientific Notation

- The exponent, or power-of-10, is increased by one for every place the decimal point is shifted to the left.
  - $360{,}000 = 3.6 \times 10^5$
- The exponent, or power-of-10, is decreased by one for every place the decimal point is shifted to the right.
  - $0.0694 = 6.94 \times 10^{-2}$

Base-10 → Convenient

- Easy expression and conversion
- Metric examples vs. *British examples*
  - 1 kilometer = 1000 meters
  - *1 mile = 5280 feet*
  - 1 meter = 100 centimeters
  - *1 yard = 3 feet or 36 inches*
  - 1 liter = 1000 milliliters
  - *1 quart = 32 ounces or 2 pints*
  - *1 gallon = 128 ounces*

Commonly Used Prefixes

- Mega, M
  - 10^6 or 1,000,000 times
- Kilo, k
  - 10^3 or 1,000 times
- Centi, c
  - 10^{-2} or 1/100th
- Milli, m
  - 10^{-3} or 1/1000th

Units
- Length: Meter
- Mass: Kilogram
- Time: Second
- Volume: Liter

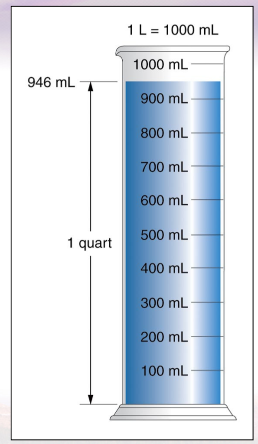
Liter – Nonstandard Metric Unit

- Liter – volume of liquid in a 0.1m (10 cm) cube (10cm x 10cm x 10cm = 1000 cm^3)
- A liter of pure water has a mass of 1 kg or 1000 grams.
- Therefore, 1 cubic cm (cc) of water has a mass of 1 gram.
- By definition 1 liter = 1000 milliliters (ml)
- So, 1 ml = 1 cc = 1 g of pure water.
- 1 ml = 1 cc for all liquids, but other liquids do not have a mass of 1 g

Units
- Length: Meter
- Mass: Kilogram
- Time: Second
- Volume: Liter

Liter & Quart

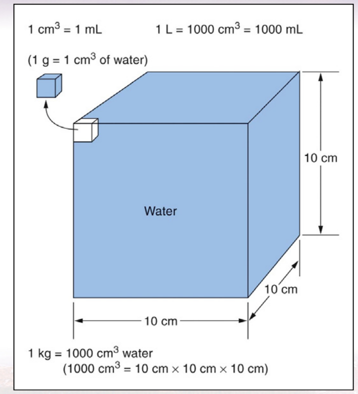
- A Liter is slightly more than a quart.
  - 1 quart = .946 liter
  - 1 liter = 1.06 quart



Units
- Length: Meter
- Mass: Kilogram
- Time: Second
- Volume: Liter

The Kilogram

- (1 kg = 2.2046 lb on earth)
- The amount of water in a 0.10m (10 cm) cube ($0.10m^3$)



MEASUREMENTS / SI UNITS

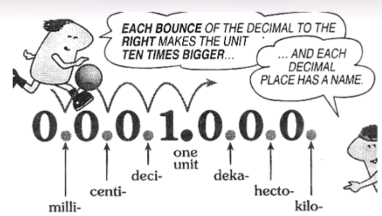
SI Base Units

	Quantity Measured	Units	Symbol
⇒	Length	Meter	m
⇒	Mass	Kilogram	kg
⇒	Time	Seconds	s
⇒	Temperature	Kelvin	K
	Electric current	Ampere	A
	Amount of substance	Mole	mol
	Intensity of light	Candela	cd

Derived Units

	Quantity Measured	Units	Symbol
⇒	Volume	Liter	L
⇒	Density	grams/cc	g/cm^3

Conversion of Units



SI PREFIXES

Prefixes	*Symbol*	*Multiplying factor*
mega-	M	1,000,000
kilo-	k	1000
centi-	c	0.01
milli-	m	0.001
micro-	µ	0.000,001

SIGNIFICANT FIGURES

Multiplication and Division

1. The LAN is the number with the least number of significant figures.
2. The answer (*product* or *quotient*) can have no more significant figures than the LAN.

Example:

Calculate the volume of a rectangular solid that has a length of 4.16 cm, a width of 2.2 cm, and a height of 2.00 cm.

Volume = Length x Width x Height

Volume = (4.16cm) (2.2cm) (2.00cm)
LAN

~~Volume = 18.304 cm^3 *(incorrect)*~~

Volume = 18 cm^3 (correct)

Examples

2 x 3 =
12 x 3 =
12 x 12 =
102 x 3 =
100 x 100 =
1 / 2 =

SIGNIFICANT FIGURES

The Leaset Accurate Number (LAN) determines the number of digits to which the answer is expressed.

Addition and Subtraction

1. The LAN is the number with the least number of digits following the decimal point.
2. The answer (*sum* or *difference*) can have no more digits *following* the decimal point than the LAN.

Example:

What is the total mass of a mixture made by mixing the following substances?

212	g water (LAN)
1.8	g salt
1.88	g sugar
~~215.98~~	~~g *(incorrect)*~~
216	g (correct)

Examples

12 + 10 =
100 + 1 =
12.3125783 + 1 =
14 + 10 =
60.0 + 10.001 =

Derived Units and Conversion Factors

(This is the stuff we will be doing a lot of)

- It is difficult to make all measurements with only the 7 fundamental units.
- Derived units are therefore used, these are multiples/combinations of fundamental units.
- We've already used derived units Volume → $length^3$, m^3, cm^3
- Area → $length^2$, m^2, ft^2, etc.
- Speed → length/time, m/s, miles/hour, etc.

Density

- <u>Density</u> (d) = mass per unit volume
- d=*m/v* [or m/$length^3$ (since v = $length^3$)]
- How "compact" a substance is
- Typical Units used – g/cm^3, kg/m^3
- Al = 2.7 g/cm^3,Fe = 7.8 g/cm^3, Au = 19.3 g/cm^3
- Average for solid earth = 5.5 g/cm^3

Liquid Densities

(Ways to measure density)

- <u>Hydrometer</u> – a weighted glass bulb
- The higher the hydrometer floats the greater the density of the liquid
- Pure water = 1g/cm^3 (exact number)
- Seawater = 1.025 g/cm^3
- Urine = 1.015 to 1.030 g/cm^3
- Hydrometers are used to 'test' antifreeze in car radiators – actually measuring the density of the liquid

Unit Combinations

(We will be doing this later in the class, don't worry yet)

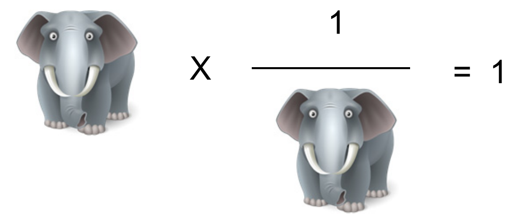
- When a combination of units becomes complex and frequently used –
- It is given a name
  - newton (N) = kg x m/s^2
  - joule (J) = kg x m^2/s^2
  - watt (W) = kg x m^2/s^3

Conversion Factors
(Important Stuff)

- Relates one unit to another unit
- Convert British to Metric (1in → cm)
- Convert units within system (1kg → g)
- We use "conversion factors" – many are listed on inside back cover of book
- 1 inch is equivalent to 2.54 centimeters
- Therefore "1 in = 2.54 cm" is our conversion factor for inches & centimeters

41

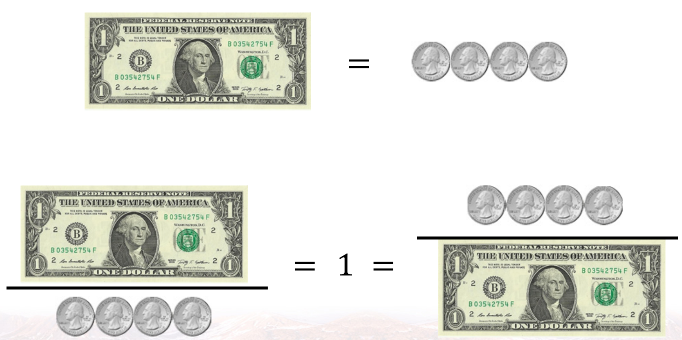
Why Conversion is Easy…



moo

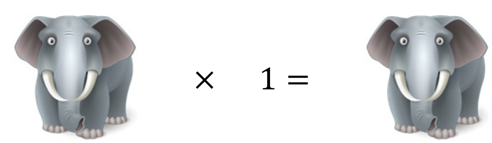
42

More with Conversions



43

More with Conversions



44

Easy Conversion Example

- *Question: How many centimeters are there in 65 inches?*
- Since 1 in = 2.54 cm → **$\frac{1\ \text{inch}}{2.54\ \text{cm}} = 1$**
- Or **$\frac{2.54\ \text{cm}}{1\ \text{in}} = 1$**
- 65 in. x $\frac{2.54\ \text{cm}}{1\ \text{in}}$ = 170 cm *(the inches cancel out!!)*

Steps to Convert

- Step 1 - Choose/Use a Conversion Factor, generally can be looked up.
- Step 2 – Arrange the Conversion Factor into the appropriate form, so that unwanted units cancel out.

$$\frac{1 inch}{2.54\ cm} \quad or \quad \frac{2.54\ cm}{1 inch}$$ *for example*

- Step 3 – Multiply or Divide to calculate answer.
- Use common sense – anticipate answer!

50 km/h → ?? mi/h

- How fast in mi/h is 50 km/h?
- Conversion Factor is 1km/h=0.621mi/h

50 km/h x $\frac{0.621 mi/h}{1 km/h}$ = 31.05 mi/h

Starting Value ***Conversion Factor*** ***Result***

30 mi/h

50 km/h → ?? mi/h

50 km/h x $\frac{0.621 mi/h}{1 km/h}$ = 31.05 mi/h

Starting Value ***Conversion Factor*** ***Result***

30 mi/h

50 mi/h → ?? km/h

- Either Conversion Factor can be used:
- 1km/h = 0.621mi/h
- How fast in km/h is 50 mi/h?

$$50 \text{ mi/h} \times \frac{1 km / h}{0.621\, mi / h} = 80.5 \text{ km/h}$$

80 km/h

Starting Value — **Conversion Factor** — **Same Result**

Multi-Step Conversion
No Problem!

- 22 inches = ?? Meters
- Inches → centimeters → meters

$$22 \text{ in} \times \frac{2.54 cm}{1 in} \times \frac{1 m}{100\ cm} = 0.56 \text{ m}$$

Starting Value — **Conv. Factor #1 in → cm** — **Conv. Factor #2 cm → m** — **Result**

Multi-Step Conversion
No Problem!

$$22 \text{ in} \times \frac{2.54 cm}{1 in} \times \frac{1 m}{100\ cm} = 0.56 \text{ m}$$

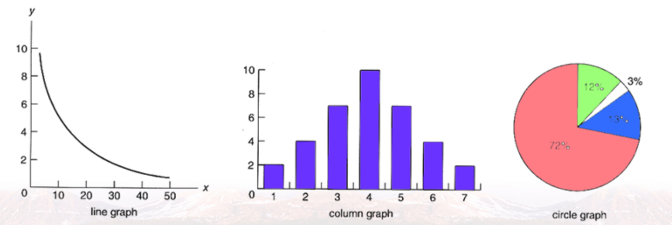
Starting Value — **Conv. Factor #1 in → cm** — **Conv. Factor #2 cm → m** — **Result**

Problem Solving

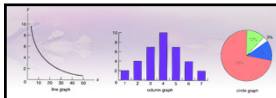
- Read the problem, and identify the chapter principle that applies to it. Write down the given quantities w/ units. Make a sketch.
- Determine what is wanted – write it down.
- Check the units, and make conversions if necessary.
- Survey equations – use appropriate one.
- Do the math, using appropriate units, round off, and adjust number of significant figures.

GRAPHING DATA

A graph is a diagram that represents the variation of one data set in relation to the resulting variation of one or more other data sets. Scientists use graphs to display and correlate data more easily and derive fundamental relationships from them. Three common types of graphs are shown in the diagram below.



53



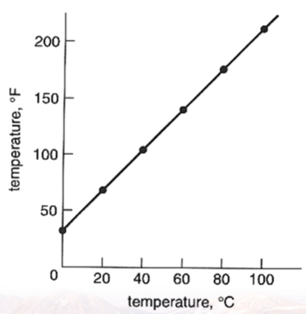
A line graph is used to compare the values of two variables. The independent variable is plotted along the x-axis, while the dependent variable is plotted along the y-axis. The independent variable is the property that is varied by the experimenter, and the dependent variable is the property that is measured in the experiment.

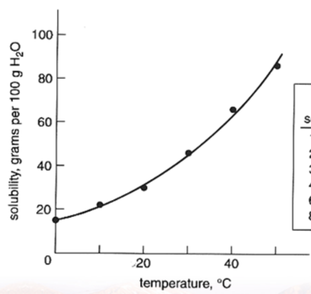
A bar or column graph is used to compare the values of several individually collected data, such as number of students in a class with a particular grade, or the tear-strength of various plastic materials. A pie or circle graph is used to show the relationship of a part to the whole, such as percent composition of elements in a compound, or percent of monthly budget used for various expenditures.

The most common type of graph used in scientific work is a line graph. Shown below are two examples of data plotted as line graphs. Note that not all line graphs are straight lines, and not all data points intersect the graph.

54

Some more examples…





sol'y	temp
15	0
22	10
30	20
46	30
66	40
86	50

55

Let's plot some equations

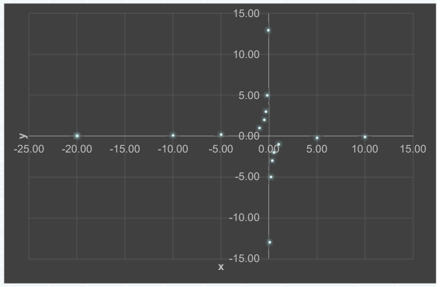
$$y = 3x + 1$$

$$xy = -1$$

56

$xy = -1$

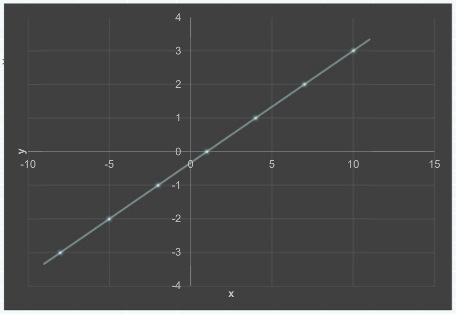
y	x
-20.00	0.05
-1.00	1.00
-0.50	2.00
-0.33	3.00
-10.00	0.10
-0.20	5.00
-0.08	13.00
-5.00	0.20
-20.00	0.05
1.00	-1.00
0.50	-2.00
0.33	-3.00
10.00	-0.10
0.20	-5.00
0.08	-13.00
5.00	-0.20



57

$y = 3x + 1$

y
1
4
-2
7
-5
-8
10



58

An example of a word problem…

Convert the density of water, 1.00 g/mL into pounds per cubic foot (lbs/ft^3)

59

Convert the density of water, 1.00 g/mL into pounds per cubic foot (lbs/ft^3)

Know

Density of water = 1.00 g/mL
1 cm^3 = 1 mL (exact)
2.54 cm = 1 inch (exact)
12 inches = 1 foot (exact)
1 pound = 453.592 grams

Find

Density of water in:
lbs/ft^3

60

pounds/cm³

pounds/mL

pounds/in³

1.00 g/mL

pounds/ft³

Know

Density of water = 1.00 g/mL
$1\ cm^3 = 1\ mL$ (exact)
2.54 cm = 1 inch (exact)
12 inches = 1 foot (exact)
1 pound = 453.592 grams

Find

Density of water in lbs/ft^3

http://themalloryfamily.net

61

1.00 g/mL → pounds/mL → pounds/cm³ → pounds/in³ → pounds/ft³

$$\frac{1.00\,\cancel{g}}{\cancel{mL}} * \frac{1\ pound}{453.592\ \cancel{g}} * \frac{1\ \cancel{mL}}{1\ \cancel{cm^3}} * \left(\frac{2.54\ \cancel{cm}}{1\ \cancel{inch}}\right)^3 * \left(\frac{12\ \cancel{inch}}{1\ foot}\right)^3$$

http://themalloryfamily.net

62

1.00 g/mL → pounds/mL → pounds/cm³ → pounds/in³ → pounds/ft³

$$\frac{1.00\ * 2.54^3\ * 12^3\ pound}{453.592\ foot^3} =$$

http://themalloryfamily.net

63