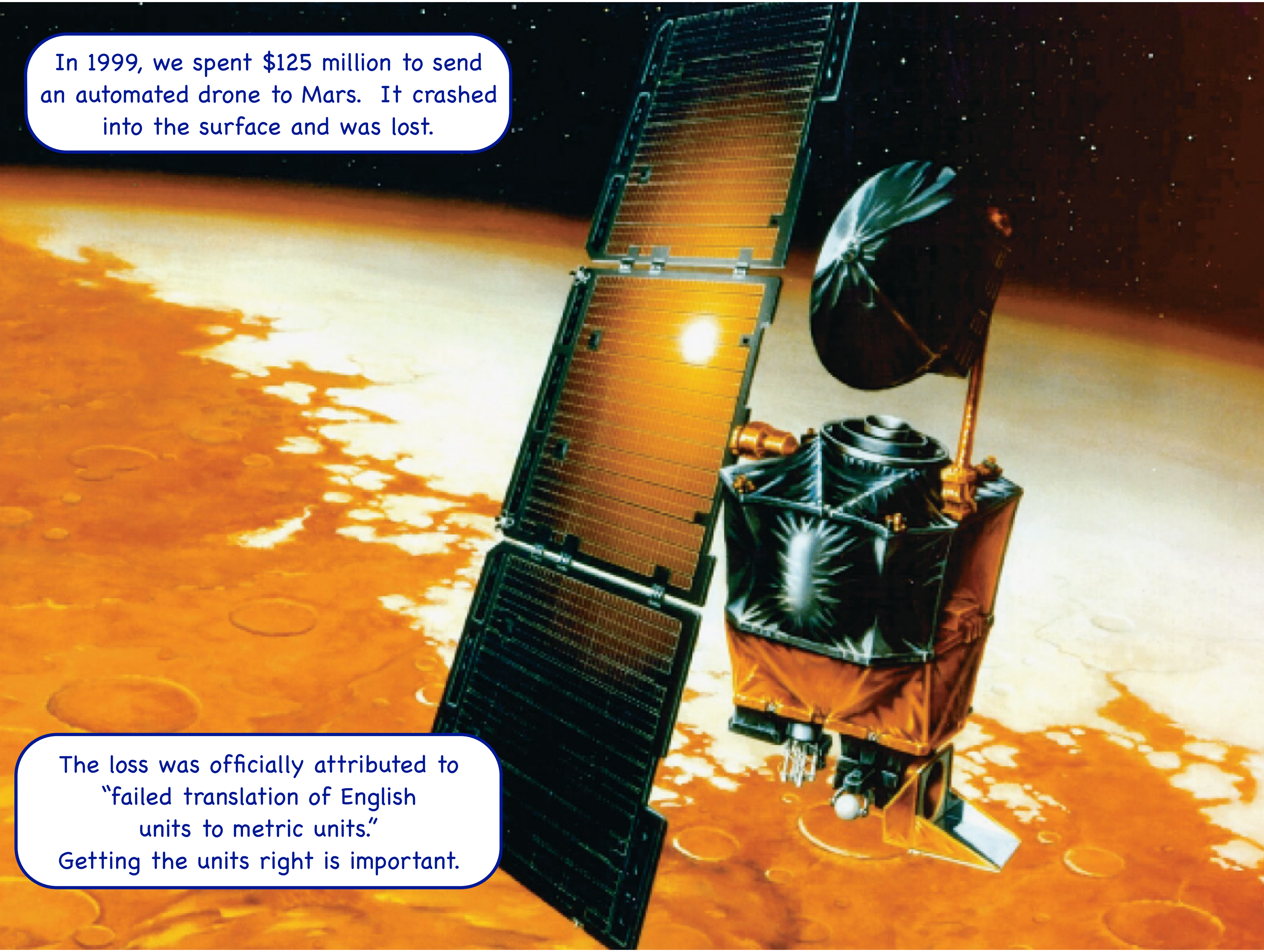
Ch02

Dimension

Measurements include both a factor and a dimension.

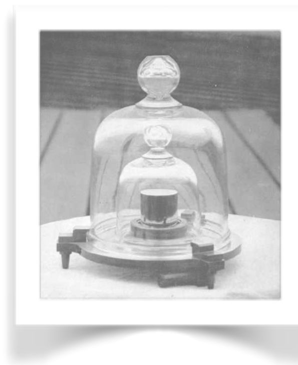
We need to understand the dimension for the factor to have meaning.

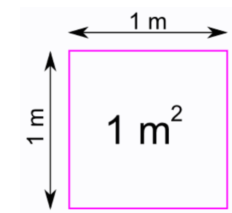
version 1.5

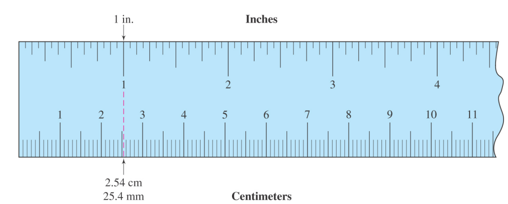

In 1999, we spent $125 million to send an automated drone to Mars. It crashed into the surface and was lost.
The loss was officially attributed to "failed translation of English units to metric units." Getting the units right is important.

Managing Dimensions

- Dimensions
  - Dimensions and their units
  - Standard units
    - Length, Mass, Time, Temperature, Counting, Current, Luminosity
    - SI Prefixes (Giga through Femto)
  - Derived units
    - Hertz, area, volume, speed, density…
  - Measuring by Difference
- Changing Dimensions
  - Trading Units
    - Within a system of measurement
    - Between related systems of measurement
    - Between related properties of substances
  - Conversion Factors
    - prefixes are conversion factors
    - other conversion factors you are responsible for memorizing
- Using Dimensional Analysis (proofs)
  - Setting up the problem
  - sort-strategy-solve-check
    - check sig figs; check units; is it reasonable







Dimension

Dimension

noun di·men·sion

: a measurement in one direction

(such as the distance from the ceiling to the floor in a room)

: a part of something

: one of the factors making up a complete personality or entity

— Webster

Dimension

- To quantify our observations about a sample we put numbers to it’s different dimensions.
- We can observe it’s:
  - Height
  - Width
  - Length

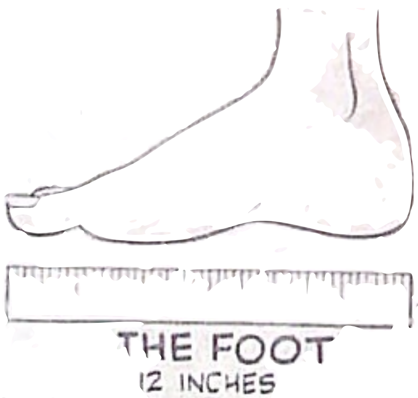
Dimension

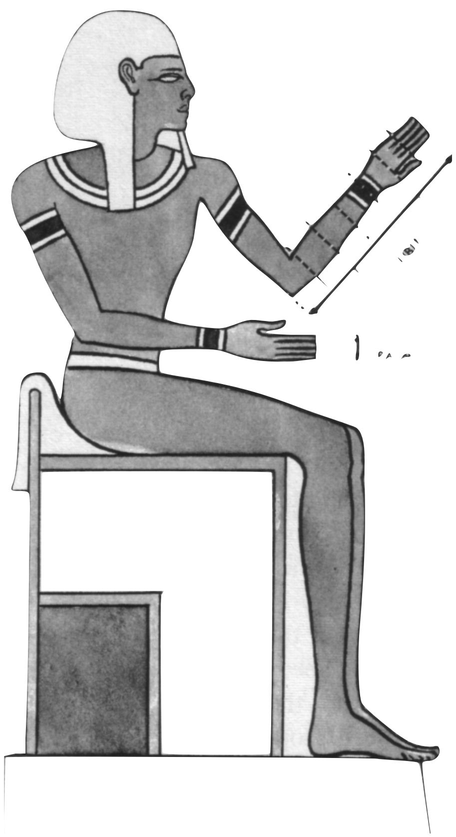
- To quantify our observations about a sample we put numbers to it's different dimensions.
- We can observe it's:
  - Height
  - Width
  - Length
- There many properties to consider in understanding samples of matter.
  - Mass
  - Volume
  - Color
  - Temperature
    - These are the some of the dimensions we measure to empirically understand sample.

Dimension

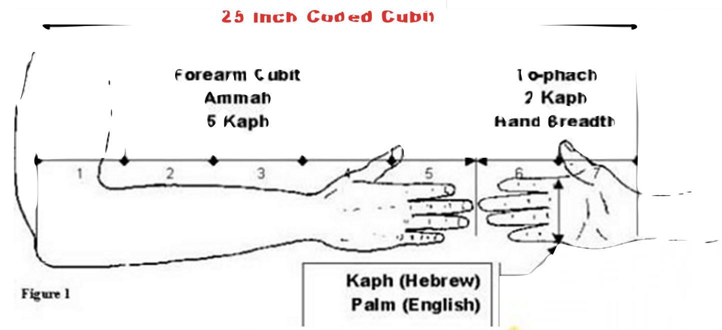
- A measurement is a count of how many of something exists in that dimension.
  - How many inches exist in it's length.
  - How many pounds exist in it's mass.
  - How many degrees exist in it's temperature.
- For that measurement to mean something we need to agree on a base unit we're counting in each dimension.
- The measurement won't mean something to anyone else (or to us a later time) if the size of that unit is different.
- One way to make sure the unit never changes is to agree on a standard which defines the unit.

Measurements require a Standard.



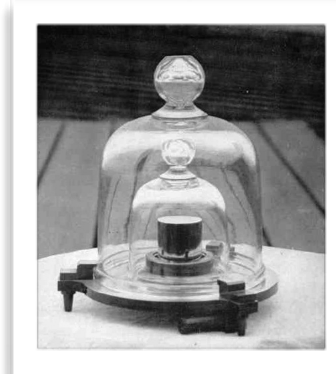


- Measurements require an agreed upon unit.
- How many of those units exist in a given dimension is the measurement.
- Units need to be defined in a way that their definition can be shared and referenced.
  - We call those definitions standards.
- Units of measurement were originally based on physical objects.
  - The foot (based on a king's foot)
  - The cubit (based on a tradesman's forearm)
  - The hand (based on the hand)
  - The stone (based on a stone)…
- But as we needed to share that information farther and more reliably.
- Today we use a system of units called SI
- It's based (mostly) on physical constants, standards we can always reproduce by doing a simple experiment.
  - The speed of light.
  - The decay of a radioactive element.
  - The boiling point of pure water.
  - … except for mass. We still use a stone.



Base Units of SI

The SI (system international) system provides units for just about everything we measure. All those units are built on just seven fundamental (base) units — standard units.



Length	meter	(m)
Mass	kilogram	(kg)
Time	second	(s)
Temperature	kelvin	(K)
Count	mole	(mol)
Current	ampere	(A)
Brightness	candela	(cd)

Meter : The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

Kilogram : The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

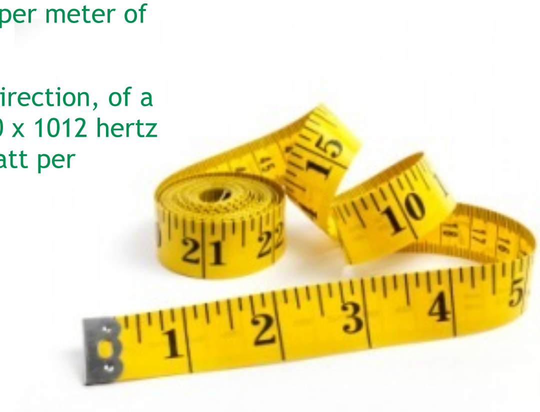
Second : The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.

Kelvin : The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Mole : The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is “mol."

Ampere : The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2 x 10-7 newton per meter of length.

Candela : The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.



For Exam #1 you are responsible for the first four: m, kg, s, and K
Moles will be introduced later.
We won’t be making use of the other two.

SI Prefixes scale SI units.

- SI Units use standard prefixes for all base units.
  - The prefix indicates the power of 10 by which you should scale the base unit.
- You are responsible for knowing prefixes Giga through Femto and being able to convert between them.

kilo means "x1000" or "x10^3"

1 kg = 1 x1000 g = 1000 g

2 kg = 2 x1000 g = 2000 g

micro means "x10^{-6}"

1 μs = 1 x10^{-6} s = 10^{-6} s

7.3 μs = 7.3 x10^{-6} s = 7.3 x10^{-6} s

milli means "x10^{-3}"

1 mm = 1 x10^{-3} m = 10^{-3} m

2.43 x10^5 mm = 2.43 x10^5 x10^{-3} m
= 2.43 x 10^2 m

exa	E	x 1,000,000,000,000,000,000	x 10^{18}
peta	P	x 1,000,000,000,000,000	x 10^{15}
tera	T	x 1,000,000,000,000	x 10^{12}
giga	G	x 1,000,000,000	x 10^{9}
mega	M	x 1,000,000	x 10^{6}
kilo	k	x 1,000	x 10^{3}
deci	d	x 0.1	x 10^{-1}
centi	c	x 0.01	x 10^{-2}
milli	m	x 0.001	x 10^{-3}
micro	μ	x 0.000001	x 10^{-6}
nano	n	x 0.000000001	x 10^{-9}
pico	p	x 0.000000000001	x 10^{-12}
femto	f	x 0.000000000000001	x 10^{-15}
atto	a	x 0.000000000000000001	x 10^{-18}

Mega & micro are both six (3+3)

nine nano

fifteen femto

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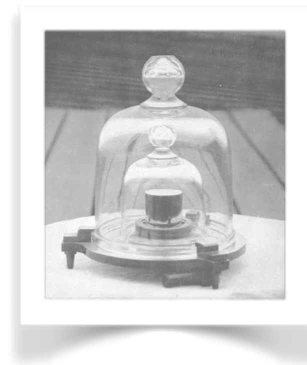
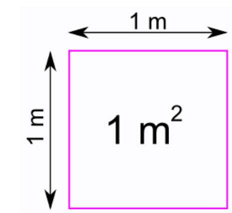
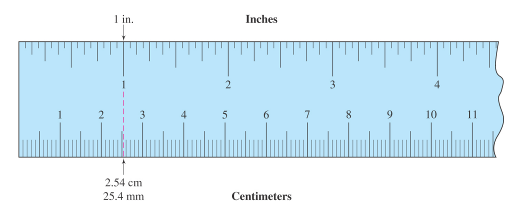






Derived Units

- Not all units are standard units.
- Some units are derived from other units.

	SI derived unit	
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2
wave number	reciprocal meter	m^{-1}
mass density	kilogram per cubic meter	kg/m^3
specific volume	cubic meter per kilogram	m^3/kg
current density	ampere per square meter	A/m^2
magnetic field strength	ampere per meter	A/m
amount-of-substance concentration	mole per cubic meter	mol/m^3
luminance	candela per square meter	cd/m^2
mass fraction	kilogram per kilogram, which may be represented by the number 1	kg/kg = 1

These units have no standard.

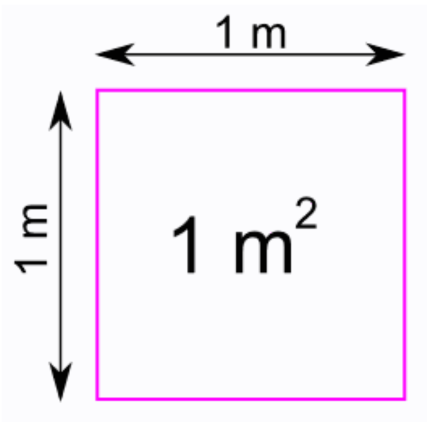
There is no golden m^3 in a bell jar to compare with.

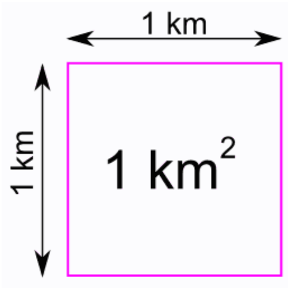
Derived Units

- Not all units are standard units.
- Some units are derived from other units.
  - Frequency is measured in Hertz, equal to one over a second (1/s). There is no golden unit of Hertz in bell jar somewhere (like there is for the kilogram). But we can all agree on what a Hertz is because there is a golden measure of seconds.

$$1 \text{ Hertz} = 1 \text{ s}^{-1} = \frac{1}{\text{s}}$$

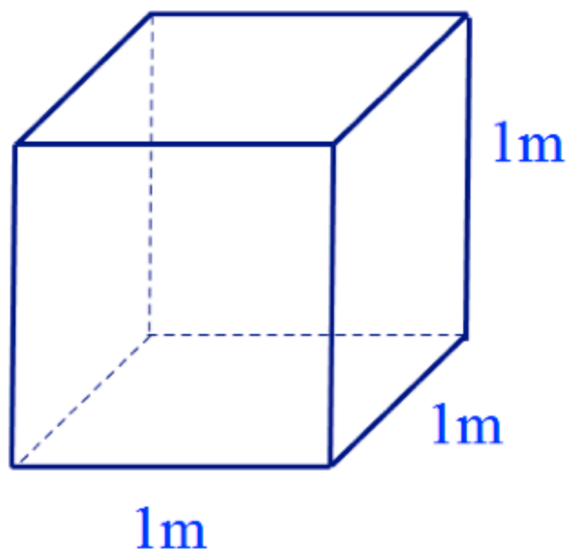
  - Area is measured in meters squared (m^2). We can't compare a m^2 to a standard to make sure it's right. But we know how many meters light travels in a second, so can derive a m^2 whenever we need to compare it.
    - Sometimes it's more convenient to use km^2 or inches squared.
    - Those units are derived similarly.





Derived Units

- Volume uses derived units.
- A unit of volume is a cubic meter (m^3)
  - There is no golden cubic meter.
    - We don't need one.
  - We have a perfect reference for a meter, we can always derive make that golden 1 m^3 by considering a box that is exactly 1 meter on each side.



Derived Units

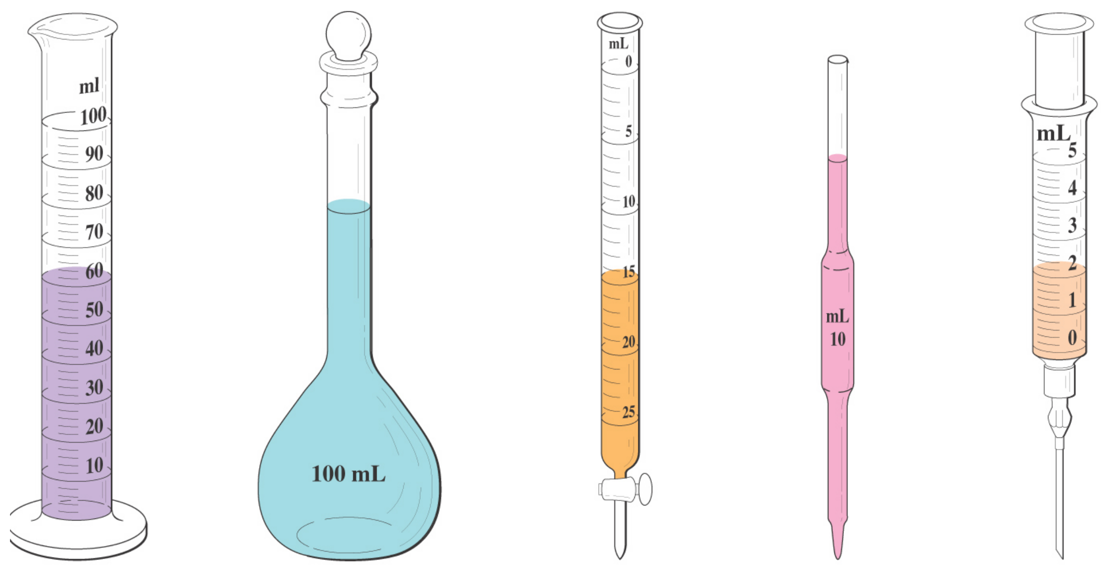
- The liter (L) is the most common measure of liquid volumes.
- A liter is defined as equal to 1/1000th of a cubic meter.
  - As chemists like to work with liquids, we'll often prefer the Liter.
- On the laboratory scale it's more convenient to work with 1/1000th of a liter, a milliliter (mL).
  - Most of our measuring tools will be calibrated for milliliters (mL).

$1\ m^3 = 1000\ L$

by Definition

$1\ mL = 10^{-3}\ L$

by Definition



Graduated cylinder

Volumetric flask

Buret

Pipet

Syringe

Derived Units

- A milliliter (mL) is exactly equal to 1 cm^3
- That's not a definition, it's a consequence.
- We can justify it with algebra.
- You are responsible for knowing this equivalence.
- It will come in handy when we need to convert between those units.
- We'll talk about conversion factors in a little bit.

$$1\ cm^3 = 1\ mL$$ (exactly)

justified by Proof

(a mathematical proof)

$1\ cm^3 = 1\ cm^3$

$c = 10^{-2}$

$= 1\ (10^{-2}\ m)^3$

$= 1\ (10^{-2})^3\ (m)^3$

$= 1\ (10^{-6})\ (m)^3$

$= 10^{-6}\ m^3$

$= 10^{-3} \times 10^{-3}\ m^3$

$m = 10^{-3}$

$= 10^{-3} \times 1\ L$

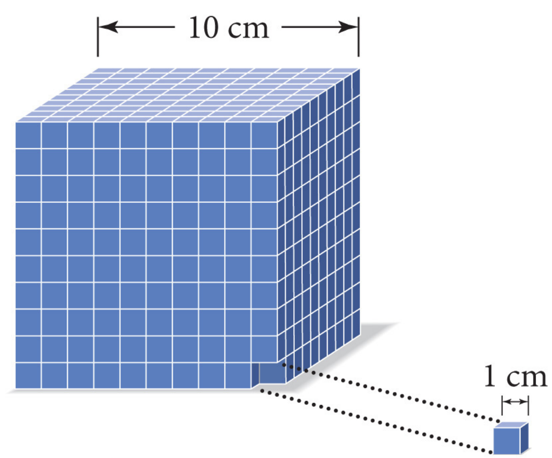
$1\ cm^3 = 1\ mL$

$$1\ m^3 = 1000\ L$$

justified by Definition

$1\ m^3 = 10^3\ L$

$10^{-3}\ m^3 = 1\ L$

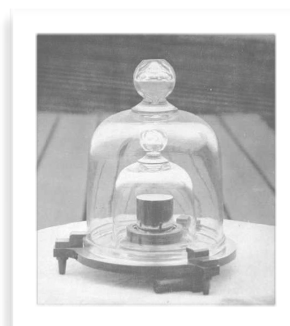


A 10 cm cube contains 1000 1 cm cubes.

Derived Units

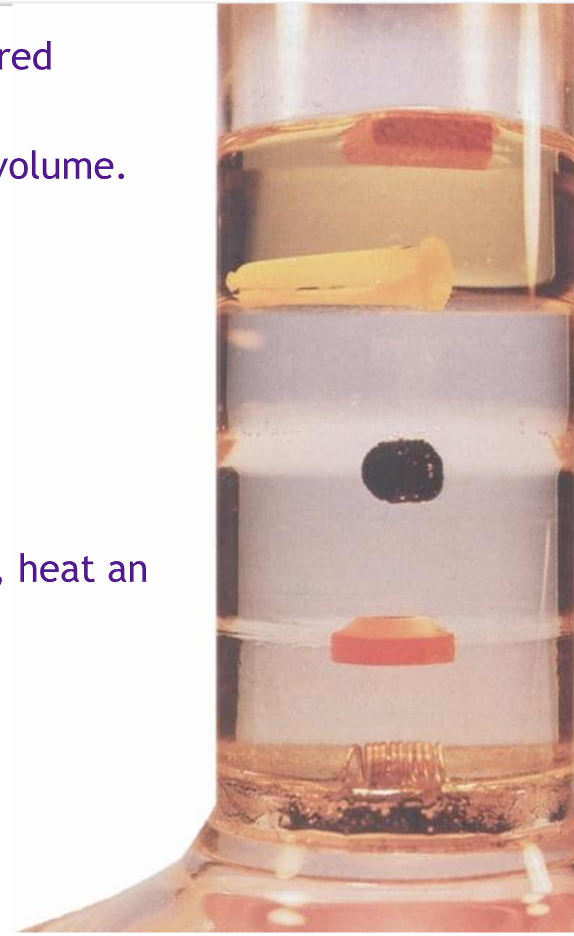
SI derived unit			
radian [a]	rad	-	$m \cdot m^{-1} = 1$ [b]
steradian [a]	sr [c]	-	$m^2 \cdot m^{-2} = 1$ [b]
hertz	Hz	-	s^{-1}
newton	N	-	$m \cdot kg \cdot s^{-2}$
pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
coulomb	C	-	$s \cdot A$
volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
weber	Wb	$V \cdot s$	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
degree Celsius	°C	-	K
lumen	lm	cd·sr [c]	$m^2 \cdot m^{-2} \cdot cd = cd$
lux	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
becquerel	Bq	-	s^{-1}
gray	Gy	J/kg	$m^2 \cdot s^{-2}$
sievert	Sv	J/kg	$m^2 \cdot s^{-2}$
katal	kat		$s^{-1} \cdot mol$

- The SI system includes about 40 units that are not based on standards.
- These units were constructed to measure a variety of interesting properties.
  - We derived those units from the seven base units.
- Many of these derived units have their own names:
  - Hertz
  - Watts
  - Volts
  - Newtons
  - Pascals
- One interesting property is density…
  - We use g/mL (or g/cm^3) to measure density.



Density

- Density is a physical property, it's one that can't be measured directly – but it can be calculated.
- Density is how much of a substance is packed into a given volume.
  - Think of it as "crowdedness."
- Density is equal to mass divided by volume.
- The most common units of density are g/ml or g/cm^3
  - These units are derived from grams and milliliters (or grams and centimeters).
- Density is a property often used to identify metals.
- The density of an object will change with it's temperature, heat an object and it get's less dense.



Substance	Density (g/cm^3)
Wood	0.7
Corn oil	0.925
Plastic	0.93
Water	1.00
Tar ball	1.02
Glycerin	1.26
Rubber washer	1.34
Corn syrup	1.38
Copper wire	8.8
Mercury	13.6

$$d = \frac{\text{mass}}{\text{volume}}$$

$$d^{4°C}_{H_2O} = \frac{1.0000 \text{ g}}{1.0000 \text{ mL}} = 1.0000 \frac{\text{g}}{\text{mL}}$$

$$d^{80°C}_{H_2O} = \frac{1.0000 \text{ g}}{1.0290 \text{ mL}} = 0.97182 \frac{\text{g}}{\text{mL}}$$

- Less dense substances will rise above (float) in more dense materials.
- Density can be used as a conversion factor to find the volume and of a substance from it's mass, or the mass from it's volume.

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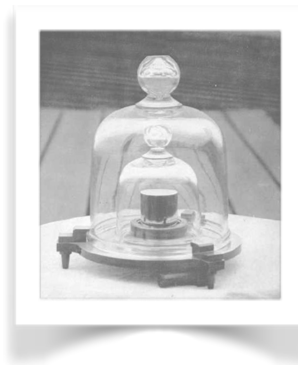
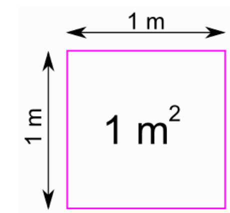
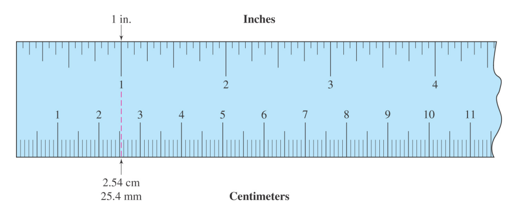




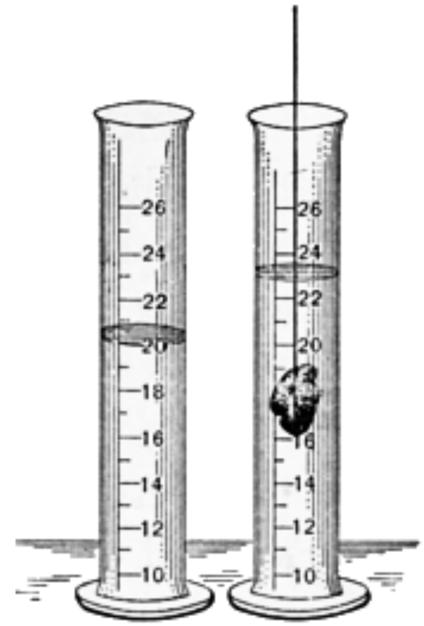


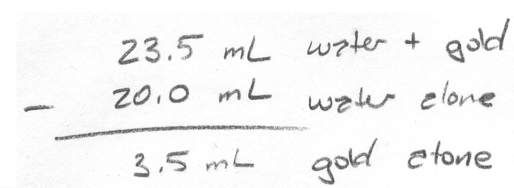
Measuring by Difference

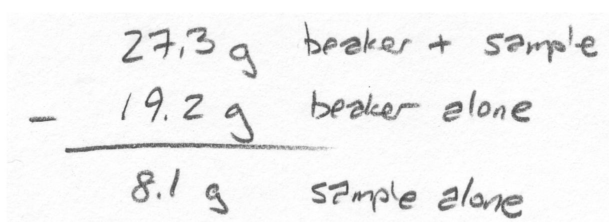
- Iron pyrite and gold have many similar properties, but gold has a remarkably unique density.

$$d_{FeS_2} = 4.80\frac{g}{cm^3} \qquad d_{Au} = 19.30\frac{g}{cm^3}$$

- During the gold rush, prospectors would identify gold by it's density.
- They would measure the mass and volume of a nugget, then divide them to find the objects density.
- Mass was easy to measure, they'd just set the nugget on a scale.
- For the volume of a solid it's easiest to measure volume using the "difference method"
  - Measure your container (water in this case)
  - Add the thing you want to know about
  - Measure again and take the difference
- In the lab, you'll use difference method for the volume of solids.
- Some of the substances you're measure will be liquids or powders, you can't set them on a scale like a gold nugget.
- You'll use a beaker and the difference method to get the mass of substances for your experiments.



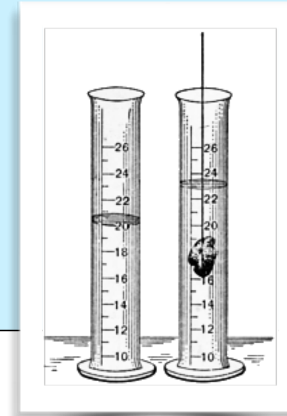




Density Calculation

Gold has a density of 19.3 g/cm^3. A nugget weights 63.88 grams. If you put the nugget in 20.00 ml of water the volume rises to 23.31 ml, what is it's density?

Is the rock gold?



① Find the volume

② Find the Density

$m = 63.88\ g$

$V = 3.31\ mL$

$$\begin{array}{r} 23.31\ mL \\ -\ 20.00\ mL \\ \hline 3.31 \end{array}$$

$V = 3.31\ mL$

$$d = \frac{m}{V} = \frac{63.88\ g}{3.31\ mL}$$

$$= 19.299093\ g/mL$$

(a) $= 19.3\ g/mL$

(b) The rock is gold.

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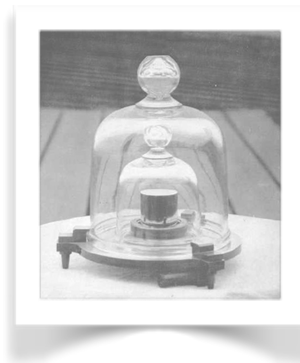
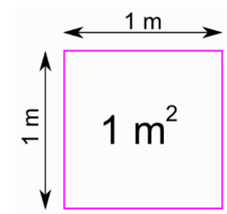
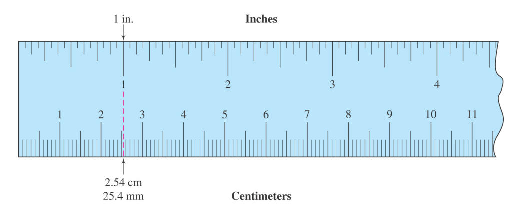






Dimensional Analysis

- Dimensional Analysis (also called Factor-Label Method or the Unit Factor Method) is a problem-solving method that uses the fact that any number or expression can be multiplied by one without changing its value.
- It's a way of taking a measurement you already have and expressing that quantity in a different dimension, using relationships between the two dimensions.
- You already do this.
  - For example, if I had a stick that measured 24 inches, you know that stick is 2 feet long.
  - You got there by dividing 24 by twelve. To say it another way, you multiplied 24 by 1/12.
  - In general, something can't be 24 and also be 2.
  - The trick is it can, if the units are different.
  - 1 foot is equal to 12 inches. So 1 foot over 12 inches is just one.
  - You didn't change the measurement, multiplying by 1 foot over 12 inches just traded the units.

$$24 \text{ inches} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 2 \text{ feet}$$

- We'll use dimensional analysis to find one measurement from another measurement:
  - Within a given measurement system…
    - ex: from inches to feet, from mL to L, from m to nm
  - Between measurement systems…
    - ex: from miles to km, from inches to cm, from grams to pounds
  - Between related properties…
    - ex: from cm^3 of gold to grams of gold (using density)

19.30 g/cm^3 means

$$19.30 \text{ g} = 1 \text{ cm}^3 \text{ (for gold)}$$

$$\text{so } \frac{19.30 \text{ g Au}}{1 \text{ cm}^3 \text{ Au}} = 1$$

$$5.0 \text{ cm}^3 \text{ Au} \times \frac{19.30 \text{ g Au}}{1 \text{ cm}^3 \text{ Au}} = 96.5 \text{ g Au} = \boxed{97 \text{ g Au}}$$

Dimensional Analysis

- How many inches are there in 13.7 feet?

Know 1 ft contains 12 inches

$13.7 \times 12 = 164.4$

so 164.4 ft

Dimensional Analysis

- How many inches are there in 13.7 feet?

$13.7\ ft = \_\_\_\_\ inches.$

$1\ ft = 12\ inches$

$1 = \frac{12\ in}{ft}$

The factor 12 was the key.

Knowing conversion factors like this will let us move between the dimensions that define the systems of measure we want to use.

And between the properties of substances we want to explore.

$13.7\ ft \times 1 =$

$13.7\ ft \times \frac{12\ in}{ft} =$

3 s.f. ∞ s.f.

$13.7 \times \frac{ft}{ft} \times 12 \times in =$

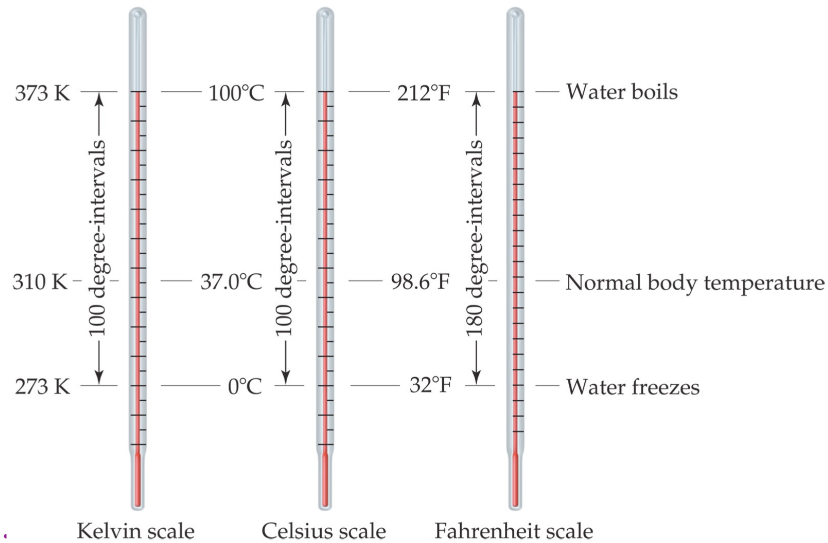
$13.7 \times 12 \times in = 164.4\ in$

$\boxed{164\ in}$

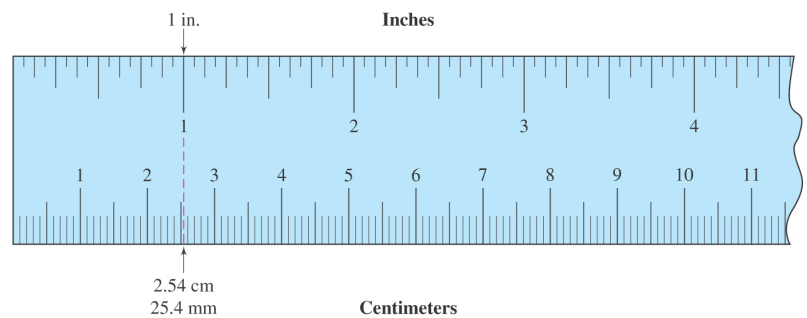
Conversion Factors

You must know if a conversion factor is exact or a measurement.

- Most conversion factors within systems are definitions, so most conversions within a system are exact.
  - 1 foot = 12 inches — exactly
  - 1 day = 24 hours — exactly
- You need to be able to convert between legacy unit systems.
- Most conversions between different systems are measured, so most conversion factors are not exact.
  - 1 kg measures 2.2 lbs (2 significant figures)
- The conversion between cm and inches is an important exception.
  - In 1959 the English system of length was redefined and is now based on the cm.
  - Since 1959, 1 inch = 2.54 cm exactly.



Length	2.54 cm = 1 inch (exact)
Mass	1 kg = 2.2 lbs (not exact)
Time	60 sec = 1 min; 60 min = 1 hr; 24 hr = 1 day; 365 day = 1 year (all exact)
Temperature	K temp = add 273.15 to ˚C temp (not exact) Fahrenheit is useless; don't worry about it.
Count	(coming soon)
Volume	1 cm^3 = 1 mL (exact)



Dimensional Analysis

- How many nm are there in 0.24 km?

$$0.24\,\text{km} \cdot \frac{1 \cdot 10^{3}\,\text{m}}{1\,\text{km}} \cdot \frac{1\,\text{nm}}{1 \cdot 10^{-9}\,\text{m}} = 2.4 \times 10^{11}\,\text{nm}$$

2 s.f.   ∞ s.f.   ∞ s.f.   2 s.f.

✦ you can link multiple factors
✦ for unit conversions always go through the base unit
✦ conversion factors within a unit system are defined

- A suitcase weights 32.4 lbs, what is the weight in grams?

$$32.4\,\text{lbs} \cdot \frac{1\,\text{kg}}{2.2\,\text{lbs}} \cdot \frac{1 \cdot 10^{3}\,\text{g}}{1\,\text{kg}} = 14{,}727\,\text{g} = 1.5 \times 10^{4}\,\text{g}$$

3 s.f.   2 s.f.   ∞ s.f.   2 s.f.

✦ conversion between unit systems are usually measurements — watch the significant figures!

- A pure gold pendent has a mass of 32.5 grams, what is it’s volume in mL?

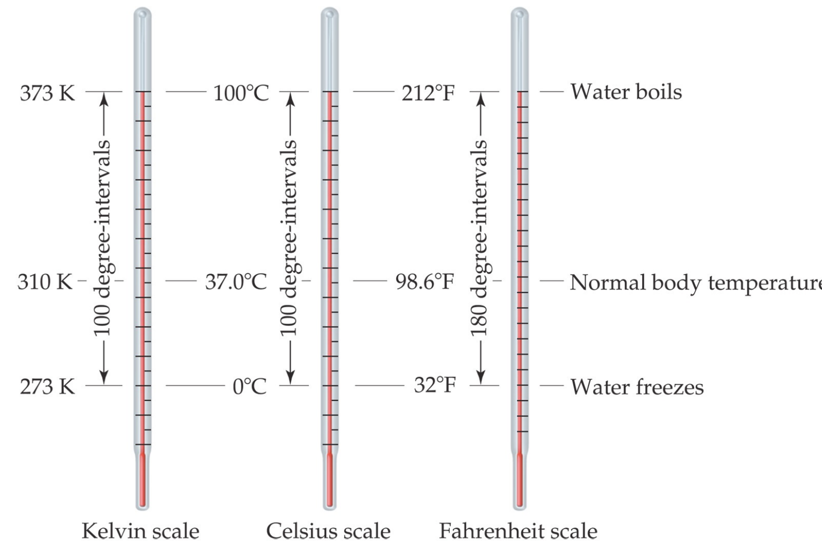
$$32.5\,\text{g Au} \cdot \frac{1\,\text{cm}^3\,\text{Au}}{19.30\,\text{g Au}} \cdot \frac{1\,\text{mL}}{1\,\text{cm}^3} = 1.6839\,\text{mL} = 1.68\,\text{mL Au}$$

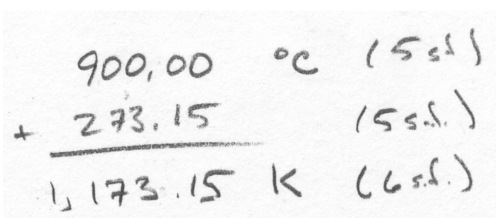
3 s.f.   4 s.f.   ∞ s.f.   3 s.f.

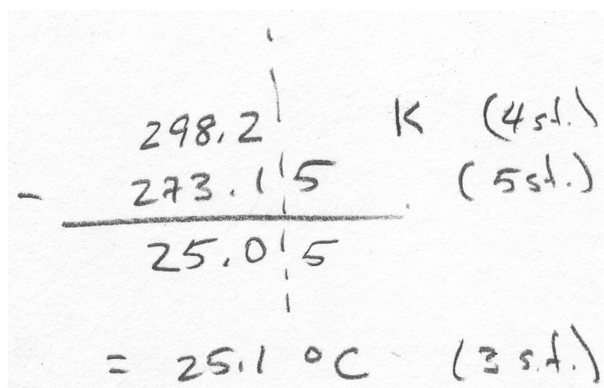
✦ properties with derived units can be used to relate two properties.
✦ conversion factors are reversible

Temperature

- Managing temperature measurements uses a different kind of conversion.
- Dimensional analysis isn't appropriate or necessary for conversions between Celsius and Kelvin.
  - I won't ask you to convert into or out of Fahrenheit.
- 1 degree Celsius is the same size as 1 degree Kelvin – they just have a different zero value.
  - To convert to Kelvin
    add 273.15 to the Celsius temperature.
  - To convert to Celsius
    subtract 273.15 from the Kelvin temperature.
- Watch significant figures!
- Addition and subtraction are tricky with sig figs.
  – *always use long hand to find the precision!*







Conversion Factors You Need to Know

Length	2.54 cm = 1 inch (exact)
Mass	1 kg = 2.2 lbs (not exact)
Time	60 sec = 1 min; 60 min = 1 hr; 24 hr = 1 day; 365 day = 1 year (all exact)
Temperature	K temp = add 273.15 to ˚C temp (not exact) Fahrenheit is useless; don't worry about it.
Count	(coming soon)
Volume	1 cm^3 = 1 mL (exact)

giga	G	x 1,000,000,000	x 10^{9}
mega	M	x 1,000,000	x 10^{6}
kilo	k	x 1,000	x 10^{3}
deci	d	x 0.1	x 10^{-1}
centi	c	x 0.01	x 10^{-2}
milli	m	x 0.001	x 10^{-3}
micro	μ	x 0.000001	x 10^{-6}
nano	n	x 0.000000001	x 10^{-9}
pico	p	x 0.000000000001	x 10^{-12}
femto	f	x 0.000000000000001	x 10^{-15}

Mega & micro are both six (3+3)

nine nano

fifteen femto

Examples

kilo means "x1000" or "x10^{3}"

1 kg = 1 x1000 g = 1000 g

2 kg = 2 x1000 g = 2000 g

micro means "x10^{-6}"

1 μs = 1 x10^{-6} s = 10^{-6} s

7.3 μs = 7.3 x10^{-6} s = 7.3 x10^{-6} s

milli means "x10^{-3}"

1 mm = 1 x10^{-3} m = 10^{-3} m

2.43 x10^{5} mm = 2.43 x10^{5} x10^{-3} m = 2.43 x 10^{2} m

Ch02

Managing Dimensions

- Dimensions
  - Dimensions and their units
  - Standard units
    - Length, Mass, Time, Temperature, Counting, Current, Luminosity
    - SI Prefixes (Giga through Femto)
  - Derived units
    - Hertz, area, volume, speed, density…
  - Measuring by Difference
- Changing Dimensions
  - Trading Units
    - Within a system of measurement
    - Between related systems of measurement
    - Between related properties of substances
  - Conversion Factors
    - prefixes are conversion factors
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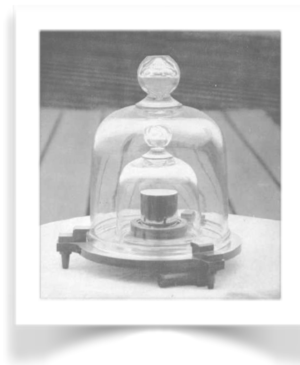
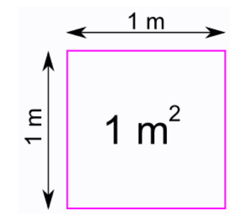
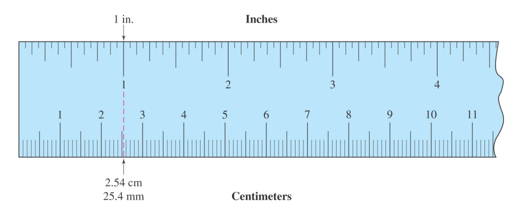
  - sort-strategy-solve-check
    - check sig figs; check units; is it reasonable







Gold Rings

The price of gold is $48.91 per gram. How much would you have to spend to make seven rings that each use 0.0153 L of gold? Gold has a density of 19.3 g/mL.

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2 strategy

1 sort

3 solve

4 check

Gold Rings

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$1\,g = \$48.91$

$1\,ring = 0.0153\,L$

$1\,mL = 19.3\,g$

$1\,mL = 10^{-3}\,L$

$$Rings \rightarrow L \rightarrow mL \rightarrow g \rightarrow \$$$

$$7\,rings \cdot \frac{0.153\,L}{1\,ring} \cdot \frac{1\,mL}{10^{-3}\,L} \cdot \frac{19.3\,g}{1\,mL} \cdot \frac{\$48.91}{1\,g} =$$

$$= \$101{,}098.4373$$

$$= \$101{,}000$$

$$= \boxed{\$1.01 \times 10^{5}}$$

Glass Statue

Glass has a density of 2.6 g/cm^3. What's the weight in kg of a glass statue that has a volume of 42.3 in^3?

2 strategy

1 sort

3 solve

4 check

Glass Statue

Glass has a density of 2.6 g/cm^3. What's the weight in kg of a glass statue that has a volume of 0.0423 m^3?

$2.6\ g/cm^3$

$2.6\ g = 1\ cm^3$

$1\ kg = 10^3\ g$

$1\ cm^3 = 10^{-6}\ m^3$

① Find $m \rightarrow cm^3$ Factor

② $m^3 \rightarrow cm^3 \rightarrow g \rightarrow kg$

$1\ cm = 1\ cm$

$1\ cm = 10^{-2}\ m$

$(1\ cm)^3 = (10^{-2}\ m)^3$

$(1)^3\ cm^3 = (10^{-2})^3\ m^3$

$1\ cm^3 = 10^{-6}\ m^3$

$$0.0423\ m^3 \cdot \frac{1\ cm^3}{10^{-6}\ m} \cdot \frac{2.6\ g}{1\ cm^3} \cdot \frac{1\ kg}{10^3\ g} = 109.98\ kg$$

3 sf. ∞ sf. 2 sf. ∞ sf.

$= 1.1 \times 10^2\ kg$

Soda Pop

A soda can has 335 mL of cola in it. There are four six packs in a case of cola and 108 cases in a pallet. If cola has a density of 1.048 g/mL, how many kg of cola are in a pallet of cola cans?

pallet → case → pack → can → mL → g → kg

1 can = 335 mL

4 packs = 1 case

1 pack = 6 cans

1 pallet = 108 cases

1.048 g = 1 mL

1000 g = 1 kg

$$1 \text{ pallet} \cdot \frac{108 \text{ case}}{1 \text{ pallet}} \cdot \frac{4 \text{ pack}}{1 \text{ case}} \cdot \frac{6 \text{ cans}}{1 \text{ pack}} \cdot \frac{335 \text{ mL}}{1 \text{ can}} \cdot \frac{1.048 \text{ g}}{1 \text{ mL}} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} =$$

∞ ∞ ∞ ∞ 3 s.f. 4 s.f. ∞

909.99936 kg

$= \boxed{9.10 \times 10^2 \text{ kg}}$

Ch02

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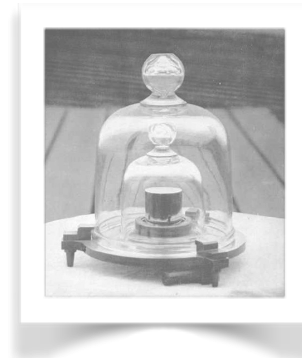

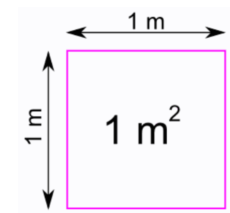

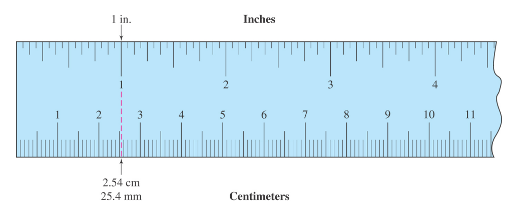

Questions?