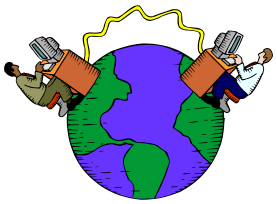
Measurement, Metrics & Dimensional Analysis

Units

Assume you run out of gas
You ask by-standers, "How far to nearest gas station?"

Bystander points left and says, "four!"
Another points right and says, "six"



Duh!!!!!!! 4 or 6 what?

4 miles, blocks, yards, feet, light-years??????

Measurements are incomplete without units
Units provide scale
Units identify type of measurement
Units provide key to solving problems

	English	**Metric**
Origin	Conquest Based on royalty	Convention based on decimal 10
Conversions	Not-uniform Not-consistent	Uniform Consistent
Communication	Confuses	Facilitates
	Regional	Universal in science

SI (Systeme International) Basic Units

How much?
- mass = gram (g)
- length = meter (m)
- time = second (s)
- chemical quantity = mole (mol)

Measurement incomplete without "units"

Absolutely essential when working problems!

Derived Units (Combination Units)

Any combination of units
Area = length x width
Volume = length x width x height
Density = mass/volume
Speed = distance / time

Volume is always a combined unit

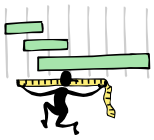
Table 3.2 Metric Prefixes*

Large Units			Small Units		
Metric Prefix	Metric Symbol	Multiple	Metric Prefix	Metric Symbol	Multiple
tera-	T	10^{12}	Unit (gram, meter, liter)		$1 = 10^0$
giga-	G	10^9	deci-	d	$0.1 = 10^{-1}$
mega-	M	$1{,}000{,}000 = 10^6$	**centi-**	**c**	$\mathbf{0.01 = 10^{-2}}$
kilo-	**k**	$\mathbf{1{,}000 = 10^3}$	**milli-**	**m**	$\mathbf{0.001 = 10^{-3}}$
hecto-	h	$100 = 10^2$	micro-	μ	$0.000001 = 10^{-6}$
deca-	da	$10 = 10^1$	nano-	n	10^{-9}
Unit (gram, meter, liter)		$1 = 10^0$	pico-	p	10^{-12}

*The most important prefixes are printed in **boldface**.

Metric Prefixes

kilo-
Larger; multiply by 1000



centi-
Smaller; divide by 100

milli-
Smaller; divide by 1000

Conversions

1000 m = 1 km
100 cm = 1 m
1000 mm = 1 m

"per expressions"

Dimensional Analysis

Problem solving technique involving "canceling" units
Provides "path" for moving from known to unknown quantities

Key to Solving Problems

1. What is being asked? (Wanted)
2. What do I know?v(Given)
3. Use "Per expressions" to move 2 ➔ 1
4."Turn the crank" (Do the math)
USE UNITS
Units wrong, most likely have wrong answer

Doing The Math

Measurements: Number plus unit
Arithmetic:
Add / Subtract ➔ Must have same units
Multiply / Divide ➔ Numbers & Units multiplied / divided separately

Use Per Expressions to define location of number values

example: for 1000 m = 1 km per expression

If I need to convert 345 m to km:

$$345\ \text{m} \times \frac{1\ \text{km}}{1000\ \text{m}} = 0.345\ \text{km}$$

If I need to convert 345 km to m:

$$345\ \text{km} \times \frac{1000\ \text{m}}{1\ \text{km}} = 345{,}000\ \text{m}$$

Solving Unit Conversion Problems

Process:

Write Given or Known (Left side of =)
Write Wanted (Right side of =)
Select "per expression" to cancel given unit
If units same on left and right of = , do the math
If units not the same, add another per expression
Continue "linear string" until units same on both sides of the =
Once units correct, solve as a single linear string calculation

Stepwise: Convert 345 m to km

Write "known" and "wanted"

$$345\ \text{m} \times \quad = ?\ \text{km}$$

Next, start conversion factor so starting unit "cancels"

$$345\ \text{m} \times \frac{\quad}{\text{m}} = ?\ \text{km}$$

Now, add wanted unit

$$345\ \text{m} \times \frac{\text{km}}{\text{m}} = ?\ \text{km}$$

Add the "per expression" numbers

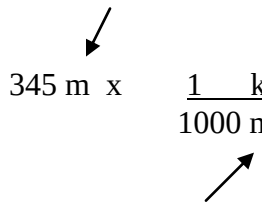
$$345\ \text{m} \times \frac{1\ \text{km}}{1000\ \text{m}} = ?\ \text{km}$$

If units "cancel" and give "wanted", then do the math

$$345\ \text{m} \times \frac{1\ \text{km}}{1000\ \text{m}} = 0.345\ \text{km}$$

To "cancel" units:

Numerator (top) of first term
Same as
Denominator (bottom) of next term



$$345\ \text{m} \times \frac{1\ \text{km}}{1000\ \text{m}} = 0.345\ \text{km}$$

Using "per expressions" to place the "numbers"

Calculate the number of milligrams in 158 grams.
1. What is the problem ➔ ? Milligrams (mg)
2. What do I know ➔ Starting with 158 g & 1000 mg = 1 g
3. Going from 2 ➔ 1

$$158\ g \times \frac{1000\ mg}{1\ g} = 158{,}000\ mg$$

Calculate the number of cm in 85.9 mm

1. What is the problem ➔ ? centimeters (cm)
2. What do I know ➔ Starting with 85.9 mm & 1000 mm = 1 m; 100 cm = 1m
3. Going from 2 ➔ 1 (as "linear string")

$$85.9\ mm \times \frac{1\ m}{1000\ mm} \times \frac{100\ cm}{1\ m} = 8.59\ cm$$

Calculate the number of L in 0.0455 kL
1. What is the problem ➔ ? Liters (L)
2. What do I know ➔ Starting with 0.0455 kL & 1000 L = 1 kL
3. Going from 2 ➔ 1

$$0.0455\ kL \times \frac{1000\ L}{1\ kL} = 45.5\ L$$

A typical texting message takes a minimum of 10 seconds.
At 60 mph (88.0 ft/sec), how much distance is traveled in 10.0 sec?

$$\frac{88.0\ ft}{sec} \times 10.0\ sec = 880\ feet$$

This corresponds to the length of

$$880\ ft \times \frac{1\ yd}{3\ ft} \times \frac{1\ football\ field}{100\ yd} = 2.93\ football\ fields$$

A fast food lunch consists of
A burger: 610 kcal
Large fries: 500 kcal
Vanilla Milk Shake: 530 kcal ➔ Total = 1640 kcals
If walking a mile takes 100 kcal,
how many miles must you walk to "burn off" this meal?

$$1640\ kcals \times \frac{1\ mile}{100\ kcals} = 16.4\ miles$$

What is Grandpa Simpson's Mileage in miles / gallon (mpg)?

$$\frac{40.0\ rod}{hogshead} \times \frac{16.5\ ft}{rod} \times \frac{1\ mile}{5,280\ ft} \times \frac{1\ hogshead}{68\ gal} = 0.00184\ mpg$$

Your car has an 18.0 gal gas tank and gets 18.2 miles per gallon.
At $3.49 / gallon, what is the gas cost to drive to Chicago (236 miles)

$$236 \text{ miles} \times \frac{1 \text{ gal}}{18.2 \text{ mi}} \times \frac{\$ 3.49}{\text{gal}} = \$ 45.25$$

How many refueling steps would be needed for a round trip?

$$\frac{236 \text{ miles}}{1 \text{ way}} \times 2 \text{ ways} \times \frac{1 \text{ gal}}{18.2 \text{ mi}} \times \frac{1 \text{ tank}}{18.0 \text{ gal}} = 1.44 \text{ tanks}$$

If tank is full when leaving, need 1 stop; return with 0.56 tank remaining

Assignment:

Continue Taking Unit1 Practice Test
Blackboard only records highest score
Take until multiple 100's have been scored (questions are variable)
The Practice Quiz is very similar to the Unit Exam
Success on Unit exam is directly related to practice exam experiences

Continue memorizing:
Conversion factors
Polyatomic Ions
Elemental Symbols

Unit 4 & 5 Have an enormous amount of memorization … best to start memorizing now!