Measurement – sidebar

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Why do we need to know this?

How much pizza should I buy for the party? How big an iPod do I need? How much carpet do I need? How long will it take me to get home tonight? Is that suitcase going to be big enough? The answer to almost every quantitative question involves measurement.

What should you know?

Standard Units

There are two systems of measurement in common use – the English system (which the book refers to as the USCS) and the metric system. Depending on where you grew up, one of these seems natural to you and the other seems alien and weird.

The most common attributes that we measure are:

Length: The most common English units are inches, feet, and miles. The most common Metric units are centimeters, meters, and kilometers. You should know where to look up exact conversion factors for these. Here is what you should know:

- The relationships within each system: There are 12 inches in a foot, there are 5280 feet in a mile. There are 100 centimeters in a meter, there are 1000 meters in a kilometer.
- The approximate relationships between the units of similar size: There are about 2.5 centimeters in an inch (look at a ruler to see how the sizes compare). There are a little more than 3 feet in a meter – a meter is just about 39 inches. There are about 1.6 kilometers in a mile – the easy thing for me to remember is that 10 kilometers (the length of a 10K race) is just about 6 miles.
- You should also have a sense of how big these are. For example, if you make a fist, you can probably find something that measures an inch and something that measures a centimeter. On me, the length of my thumbtip is about an inch and the fingernail on my forefinger is about a centimeter wide.

Heaviness: The two systems actually measure different attributes with their most common measurements. The English system measures weight in ounces, pounds, and tons. Weight is a measure of force, how strongly the object is pulled down by gravity. The Metric system measures mass in grams or kilograms. Mass is an absolute measure of how much stuff there is and doesn't depend on gravity at all. Your weight would be smaller if you were on the moon, because the moon has less gravitational pull than the earth. But your mass would be the same. Because most of our everyday measurements

are on the surface of the earth, we can use "conversion" factors, but you should know that these aren't the same kind of measurement. Here is what I expect you to know:

- The relationships within each system: There are 16 ounces in a pound, 2000 pounds in a ton, and there are 1000 grams in a kilogram.
- The approximate relationships between the units of similar size: An object that weighs an ounce on the surface of the earth has a mass of about 28 grams. An object with a mass of a kilogram weighs a little more than 2 pounds on the surface of the earth.
- You should also have an idea of how big these common measures are. For example, a US nickel measures about 5 grams while a medium-sized paper clip measures about one gram. A single serving of potato chips or dry cereal is usually one ounce.

Volume: There are dozens of volume measurements in common usage in the English system, all the way from "pinch" up through "cord." Some of the words (for example, ounce) are also used for different measurements entirely. And to make life even more complicated, there are different systems for measuring fluids and measuring dry materials. The metric system is much more reasonable – the units that measure volume are the ones you'd use in geometry; cubic meters or cubic centimeters, along with liters and milliliters. Here's what I want you to know:

- The most common English cooking measures and their relationships. There are 3 teaspoons in a tablespoon, there are 2 tablespoons in a fluid ounce, there are 8 fluid ounces in a cup, 2 cups in a pint, 2 pints in a quart, and 4 quarts in a gallon. You should be able to use these relationships to answer questions such as: How many teaspoons are in a cup? (48) How many fluid ounces in a gallon? (128)
- Some of the relationships between the volume units and other units of measure. For example, the metric system is very handy – a milliliter is identical to a cubic centimeter, and one milliliter of water has a mass of one gram. So one liter (which is a little bigger than a quart) is 1000 cc, and its mass is one kilogram, which means it weighs a little more than 2 pounds. The English system has a similar relationship. A fluid ounce of water weighs just about an ounce (hurray!), so a quart of water, which is 32 fluid ounces, weighs just about 2 pounds (hey, that matches the liter!).
- You should also have a sense of about how big these are. For example, a cubic centimeter is about the size of a die (singular of dice). An individual carton of milk is usually a half-pint (also known as cup).

Temperature: The two systems both use the word "degrees" to identify their units, so you need more information. The Fahrenheit system is the one in common use in the United States. The Celsius system is the one in common use in Canada. Here is what I expect you to know:

- The key numbers within each system: The freezing point of water is 32ºF and 0ºC. The boiling point of water is 212ºF and 100ºC. An outside temperature of 30º is quite cold if the degrees are Fahrenheit, but quite hot if the degrees are Celsius.

- The conversion formula, which is easy to remember: $F = 9/5\ C + 32$.

Time: The two systems agree on the units for measuring time. Both systems use seconds, minutes, hours, days, weeks, years, and so on.

Combining Units

In physics, all units are combinations of just a handful of basic units – units that measure length, time, mass, temperature are usually among the building blocks. By multiplying and dividing these units, you can make units to measure just about any other physical attribute. For more details, you can see http://en.wikipedia.org/wiki/Fundamental_unit.

You can combine all kinds of units in the same way. Here are some of the combinations you should know:

Area and Volume (Geometry-style): Area is measured in square units of length and volume is measured in cubic units of length. This connects to the formulas for computing areas and volumes. For example, you compute the area of a rectangle by multiplying its length by its width. If both dimensions are measured in meters, say, when you multiply them you'll get meters^2, or square meters. Those area formulas that you know and love also let you figure out the relationships between different measures of area or volume. For example, there are 12 inches in a foot, so there are 12 inches × 12 inches = 144 square inches in a square foot. There are 1000 meters in a kilometer, so there are 1000 meters × 1000 meters × 1000 meters = 1,000,000,000 meters^3 (length × width × height). There are one billion cubic meters in a cubic kilometer.

Velocity and other Rates: Velocity is a measure of how fast an object is moving. The units of velocity are length units divided by time units. Some common velocities are miles per hour, meters per second, kilometers per hour.

There are lots of other fractional units, and they can all be thought of as rates. That is, they measure how something changes. Examples of other rates: miles per gallon, dollars per hour, rpm (revolutions per minute), dollars per pound. Density (weight or mass per volume) and concentration (volume per volume) are just special kinds of rates.

Connection with your algebra class: The units of the slope of a line are fractional units (rise units over run units, in fact) – the slope of a line gives a rate.