

God's Grace to Us in Weights and Measures, Part 2

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When you buy a gallon of gasoline, how do you know that you are really getting a *gallon* of gasoline and not a smidgen less? We need some kind of standard against which to test the gasoline pump to settle that matter. Indeed, we need standard definitions of all the units of measure that we use.

There are international committees that manage the definitions of just seven so-called "basic units." All the nations of the world formally and legally accept just seven definitions of basic units. All other units are defined by conversion factors in terms of the seven basic units. The seven basic units are the kilogram, the second, the kelvin, the meter, the ampere, the mole, and the candela.

In the case of measuring mass in kilograms, we use a balance to compare the mass we want to measure against a standard mass. If you really want to be accurate, you should use the "International Prototype Kilogram," which is affectionately known as, "The Big K." The Big K is one particular actual object, one particular cylinder of platinum. It happens to be about an-inch-and-a-half in diameter and about an-inch-and-a-half high. It is kept in a special vault in a special lab on the outskirts of Paris, France. That's the best standard mass you could possibly use on your balance, because it is *the* definition of a kilogram. It became the definition of a kilogram in 1889 and it still is today.

There are also definitions for the other six basic units. In past times there was a special clock, say the clock in the town square, that was used as the definition of time, and a special meter stick, and so forth. There was one special artifact to define each basic unit. Scientists call an artifact used as a definition a "prototype unit." The Big K is the prototype unit for the kilogram.

The responsibility of caring for a prototype unit is overwhelming. It's not too hard to keep The Big K free of fingerprints and corrosion for a few months, but do this for hundreds of years? That's very hard. Likewise, keeping a clock wound up and running smoothly for a few months is one thing, but for hundreds of years? That's very hard. The responsibility is overwhelming. Because of this difficulty, for over a hundred years scientists have been looking for natural ways to define the seven basic units without resort to prototype units.

Long ago a day was defined in terms of the earth's rotation, so that a day was the time from sunrise to sunrise for a day at the solar equinox. Then a second could be defined as a fraction of this day, $1/84\,000$ of a day to be exact. We humans seem to have a special fascination for these naturally defined units of measure. Consider Stonehenge or the Mayan ruins for just two examples. Although the exact uses of these ancient sites have been lost in history, there can be no doubt that certain elements of their construction were designed to identify the equinoxes. What other purpose could there be but to mark time? Now we know that the earth's speed of rotation is slowing down slightly due to the action of the moon on the tides, so the definition of a second as a fraction of a day is archaic. In our times, a second is defined as 9 192 631 770 cycles of a certain radiation of cesium-133. Scientists have turned the experiment of measuring the frequency of radiation of cesium-133 on its head by now defining the second in terms of this radiation. They treat cesium-133 as some sort of naturally perfect tuning fork.

For a long time a meter was defined as the length of a particular platinum bar kept in France—the prototype meter. Then, to eliminate the need to maintain this prototype unit, in 1983 the meter was re-defined as the distance light travels in a vacuum in $1/299\,792\,458^{\text{th}}$ of a second. This is based on the observation that the speed of light in a vacuum is the same every time we measure it. Scientists have now turned the experiment of measuring the speed of light on its head by defining a meter in terms of the speed of light, as if the speed of light is a naturally perfect constant.

Over the past hundred years or so scientists have been redefining the seven basic units in terms of natural constants. As I record this plumbline, there is only one remaining basic unit defined in terms of a prototype standard. This last hold-out unit is the kilogram, the unit of mass. It is defined by The big K, that inch-and-a-half right cylinder of platinum in France that dates from 1889. But this is probably about to change. An international committee is planning to meet in 2014 to consider defining Planck's constant as one of these naturally occurring constants. If all goes as expected, they will use the best available measurements of Planck's constant to define Planck's constant exactly. Then the unit of mass, the kilogram, will be defined in terms of a natural constant, or actually a series of natural constants, and The big K will be relegated to functioning as a museum piece.

Do you think God upholds the creation so that the speed of light in a vacuum is a constant? And so that the frequency of radiation from cesium-133 is constant? And so that what we call Planck's constant really is constant? And how about making every electron have exactly the same constant amount of charge? And can you believe that God upholds the creation so that Boltzmann's constant never changes? And so that the luminous efficiency of radiation at 540 terahertz is always exactly 683 lumens per watt? And so that the permeability of free space is always the same? These seven natural constants of our universe are now proposed as the fundamental definitions of the seven basic units upon which we hang all our definitions of all weights and measures. Even a gallon (of gasoline) or an ounce (of gold) ultimately can be defined in terms of these natural constants, and probably will be beginning sometime in 2014.

Proverbs 16:11 says, quote, "Honest scales and balances are from the LORD; all the weights and measures in the bag are of his making," unquote. They sure are! They always have been regardless of our feeble understanding. And knowing our human limitations, I say that all the standards of measurement in the world are probably more so of God's making than we can ever imagine.

For Plumbline, I'm Professor De Boer