AIAA

AEROSPACE MICRO-LESSON

Easily digestible Aerospace Principles revealed for K-12 Students and Educators. These lessons will be sent on a bi-weekly basis and allow grade-level focused learning. - AIAA STEM K-12 Committee

METRIC UNITS OF MEASUREMENT

If we want to speak of how much there is of something, or how far it is to some place, we need units of measurement. Definitions of units have changed through the ages and there is a movement afoot to change the definition of the kilogram. The amount of mass in a kilogram would not change appreciably, but the way to figure it out would change.

GRADES K-2

If we are going to measure lengths, we need something like a ruler. A ruler gives us a standard length that we can use as our basis to compare other lengths to. For this to work, all the rulers in use need to measure the same length as one foot.

Hundreds of years ago, the "foot" was actually the length of the king's foot. If the king grew, or if the people got a different king, the length of the "foot" would change. This can cause confusion. A way to illustrate this is to mark off a length on the floor—perhaps count a number of floor tiles—and have the students pace off the length by putting their feet heel-to-toe. The different-sized students will come up with different numbers of "feet" for the same length.

*A quick read-aloud about this topic is *How Big Is a Foot?* by Rolf Myller.

GRADES 3-5

Going beyond the brief introduction for K-2 and the discussion of the need for standard units of measurement, compare the use of feet and inches to metric units like centimeters and meters. One good exercise is to have some students use yardsticks and others use meter sticks to measure a few items around the classroom, and then compare their results. Which units of measure resulted in larger numbers – inches or centimeters?

You can also lead students through a quick introduction/review of common metric prefixes – "micro," "milli," "centi," "deci," "kilo," and "mega." Can they think of other instances where they have seen these same prefixes used? Some examples are microbe, microscope, microwave, millennium, millipede, centipede, century, decimal, decade, and megaphone.

GRADES 3-5 (CONTINUED)

*A good read-aloud on this topic is *Millions to Measure* by David M. Schwartz.

GRADES 6-8

The metric system has seven basic units:

- The meter is used to measure lengths
- The kilogram is used to measure masses
- The second is used to measure times
- The ampere is used to measure electrical currents
- The kelvin is used to measure temperatures
- The mole is used to measure the amounts of things
- The candela is used to measure the brightness of light

All other measurements can be expressed in terms of these units. This might sound strange, so let's look at how some other quantities we are familiar with can be expressed in terms of base units. How about speed? Speed is how far (**distance**) something travels in a particular length of **time.** So the metric units for speed are **meters** per **second**, or m/s (length divided by time). How about acceleration? Acceleration is how much **speed** something gains in a particular length of **time**. So, the units should be the units for **speed** divided by **time** – meters per second per second, or **meters** per **second squared**. Let's try one more: force. Force is equal to **mass** times **acceleration**, so its units should be **kilograms** times **meters** divided by **seconds squared** – kg-m/s^2. These are the correct units, but you can imagine that it would get annoying always to write kg-m/s^2. For that reason, more complex units in the metric system are usually given shorthand names; in this case, the unit is called the Newton, after the famous English physicist Sir Isaac Newton. The metric system has many of these more complex *derived* units and they are often named for famous scientists. Other examples include the Joule (energy), Pascal (pressure) and Tesla (magnetism).

For more information you can consult the National Institute of Standards and Technology. Their site also has a complete list of the metric prefixes.

GRADES 9-12

When the metric units were first defined, they were based on physical objects. One meter was one ten-millionth of the distance from the North Pole of the Earth to its Equator. One liter is one thousandth of a cubic meter, and one kilogram was the mass of one liter of water. These definitions were used to construct physical prototypes for each unit; French scientists in the 1790s built a stick which they defined to be exactly 1 meter long and a weight which they defined to have exactly 1 kilogram of mass. These items were then duplicated and used as a standard of measurement across the country. However, this is not an ideal system – most materials change in size and weight as time passes, as they are handled, or even with the weather, so technically, measurements would change constantly. As measurements got more precise, scientists were put into the difficult position of changing their standards of measurement. This gets very confusing; if one measures something to be three meters long and then the definition of the meter changes, the thing is no longer three meters long. The thing has not changed, but its measurement has.

Because of this, scientists started defining the units in terms of natural phenomena that anybody can measure. Where the meter was once defined as the distance between two specific marks on a specific bar of metal (the original meter stick), it is now defined in terms of the speed of light and the second. While the second was once defined relative to the turning of the earth, it is now defined in terms of how long it takes for a specific type of atom to vibrate at a specific temperature. The only basic unit that is still defined in terms of a specific object is the kilogram, which is defined to be the mass of a certain metal cylinder that is stored in Paris (called "*le Grand K*" or "the Big K").

This may be about to change. The definition of the kilogram is being reviewed and may be changed in 2018. The amount of mass that makes up one kilogram will not change appreciably, but the way in which that amount is defined would change. (Interestingly, it seems that the reference kilogram has been changing—at least relative to the copies made of it.) You can find articles on the subject here and here.

In addition to changing the definition of the kilogram, the conference in 2018 may also change the definition of the ampere. The ampere is the unit of electrical current and is presently defined in terms of the force between two wires carrying the current. A redefinition in terms of the number of electrons flowing past a point in a wire every second is discussed here.