

Now that we have a system of units the task of actually making a measurement is reducible to three instructions;

1. Learn to use your measuring device.
2. Measure to the smallest sub-unit of the device.
3. Guess the last significant digit.

The first instruction leads directly to an important idea. Measuring requires tools. The tool can be just about anything. As an example look at measurement of length. We can make crude estimations by eye, but we can also measure the distance to the moon by radar. A common tool to measure length is the ruler. In SI the unit of length is the meter and its standard is based on the speed of light,  $c$ . The meter is defined as the distance light travels in a vacuum in  $1/299,792,458$  of a second. The justification for this definition is that  $c$  is a universal constant, and refining our measurement of  $c$  will further reduce the error of the meter rather than make any substantive change in the value, whereas the previously mentioned IPK is losing mass over time and if not accounted for will change the value of the kilogram, a disaster that has many organizations worried.

The meter is a long unit, great for measuring races and such, but not so good for finding the width of the head of a pin. To be useful for small objects, the meter has to be subdivided, many times. This brings us to the second instruction. Every measuring device has a finite scale. It can only be used to make measurements within a certain tolerance, or confidence level. This is a built in attribute of the tool and is unavoidable. It's this uncertainty which brings us to the final instruction, it makes even the finest measurement an estimation. Look once again at the common ruler. Usually they are divided into millimeters, mm, and we can estimate to a  $1/10$  mm. But is that necessarily the end of the process? It would be relatively simple subdivide each millimeter into 10 units, then we would estimate to the  $100^{\text{th}}$ , and so on until our sub-unit was on the order of atomic structure where the meaning of "edge" is unclear and this uncertainty carries over to the physical measurement of any attribute.

We can use a ruler to measure the length of a block to the millimeter and then estimate a final significant digit. In this sense we can define the precision of the instrument by the number of significant digits it makes possible, but this sense of the word is quite different from the precision of the measurement, which I'll discuss in Part III.