Measurements and Standards: The Case of the Meter

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The take-off point for this talk is an objection that originates in Wittgenstein, namely that we cannot determine the length of the standard meter as that very meter determines length. It is argued that such concerns vanish in the face of the latest conceptions of standard units like the meter. That's because (almost all) standards nowadays are not particular pieces of matter but definitions that incorporate references to fundamental physical constants. The main part of the talk involves a discussion of several presumed advantages and disadvantages of this conceptual shift. It is argued that the advantages of the shift far outweigh any disadvantages and that the last vestiges of materiality will soon make way for a purely definitional approach to all standards.

Let's travel back to Wittgenstein's time. How would one find out whether something was a meter long? By laying it against some sample meter like a ruler. And what ensured that these sample meters were a meter long? Calibration against other samples, themselves subjected to calibration in a hierarchy of sample meters whose apex was the standard meter in Paris. But what about the standard meter itself? In a well-known passage, Wittgenstein points out that the standard meter cannot be laid against itself: "There is *one* thing of which one can state neither that it is 1 metre long, nor that it is not 1 metre long, and that is the standard metre in Paris" (2009, p. 29e) [original emphasis]. The standard meter, he reasons, is a linguistic 'instrument'. As such, it provides a means through which length can be represented, though it is not itself representable. It is thus illegitimate, he claims, to ask whether the standard meter is a meter long.

Fast forward to today. As already mentioned, we nowadays rely not on material samples but on definitions that utilise fundamental physical constants.[1] The standard meter is defined as follows: "The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second" (NIST). Thus, the issue of comparing a sample to itself that so puzzled Wittgenstein doesn't even arise. The definitional approach has several presumed advantages and disadvantages. The main advantage is that it provides stability. By anchoring a standard to something invariant like a fundamental physical constant, e.g. the speed of light in a vacuum, the stability of the standard itself is bolstered. The price for such stability is that our new standards run the risk of being radically divorced from the world. Perfect vacuums, for example, are considered impossible. To address this problem, it is argued that even though some reference objects or conditions in definitions are ideal, it is still legitimate and non-trivial to use them on the basis of extrapolations from real objects and conditions. For example, we know how light slows down when passing through media whose refractive indices are progressively higher and from this knowledge we can reasonably extrapolate what the speed of light would be like if nothing impeded its path. The aforementioned and other such presumed advantages and disadvantages are discussed and the case is made that, on balance, the definitional approach offers the best way forward in matters of standardisation.

References:

National Institute of Standards and Technology (NIST) 'Reference on Constants, Units and Uncertainty', http://physics.nist.gov/cuu/Units/current.html

Wittgenstein, L. (2009) *Philosophical Investigations*, transl. by G.E.M Anscombe et al., 4th edition, Oxford: Wiley-Blackwell.

[1] Indeed, the last remaining bastion of sample-centric standards is the standard kilogram, a platinum-iridium cylinder kept at the International Bureau of Weights and Measures in Sèrves, France. Even this however is about to be replaced by a definition, with proposals to such effect having already been made.