

Cubic millimeters and inches

Charles Day

One rainy day this past summer, my wife, Jan, and I looked out of our kitchen window and noticed our neighbor's backyard was flooding. "How much water do you think is there?" she asked.

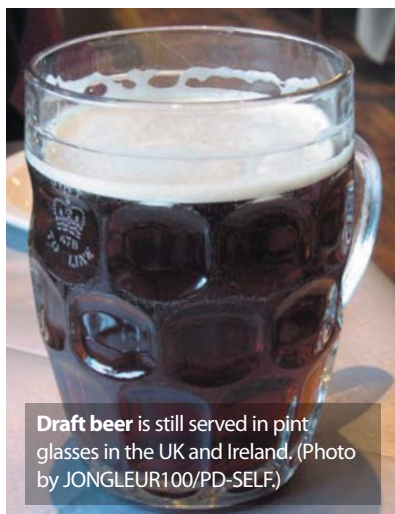
I estimated the backyard was 6 meters wide and 6 meters long. About 3 centimeters of water covered its bricked surface. Before I had finished my mental calculation of 1080 liters, Jan offered an eyeball estimate, "more than 200 gallons."

If either of us had tried to calculate an answer in imperial units, we would have estimated the yard's dimensions in feet and then converted to area in square inches. The final conversion to gallons entails remembering (or looking up) that there are 231 cubic inches in a US gallon. Whereas the metric calculation involves multiplying three numbers, the imperial one involves multiplying five numbers and dividing by a sixth.

The ease of scaling up in length and of converting length to area and volume was built into the metric system by its French founders, among them Joseph Louis Lagrange and Pierre Simon Laplace. Despite that advantage, the UK resisted—and the US continues to resist—mandating metric. Early proponents of metric in the UK included James Clerk Maxwell and William Thomson, known later as Lord Kelvin. James Joule's discovery in the 1840s that mechanical energy is equivalent to heat was one motivating factor. In 1875 Maxwell, Kelvin, and their colleagues proposed a new system of units, based on the centimeter, gram, and second. It included a new unit for energy, the erg ($1 \text{ g}\cdot\text{cm}^2/\text{s}^2$), and a new unit for force, the dyne ($1 \text{ g}\cdot\text{cm}/\text{s}^2$).

The British physicists and their allies eventually scored a partial victory. In 1896 Parliament passed an act that legalized—but didn't mandate—the use of the metric system for all purposes.

To this day, proponents of the imperial system point to its appealing basis in quotidian, human measures. An inch is roughly the length of an adult thumb's distal phalange. An acre is roughly the area of a field that a farmer driving an ox can plow in a day. The original Roman mile was the length a legionnaire covered in 1000 paces. Given that centimeters, hectares, and kilometers differ from their imperial counterparts by factors of a few or less, I don't find the human argument especially persuasive.



Draft beer is still served in pint glasses in the UK and Ireland. (Photo by JONGLEUR100/PD-SELF)



A liter is as good as a pint for ordering beer at a bar.

Some Victorian advocates of the imperial system, notably John Herschel, favored basing units on precisely engineered artifacts. Until last year, when the kilogram was redefined in terms of an arbitrarily fixed value of Planck's constant, metric units were not wholly free from reliance on artifacts. But it was the ultimate source of metric units that roused Herschel's suspicion. The meter's original definition was one ten-millionth of the distance between the North Pole and the equator as measured through Paris. Such French abstractions appalled the practical Englishman. But to Maxwell, the abstraction from nature was part of metric's appeal. As historian Simon Schaffer has noted, it reflected his belief in a divinely created, uniform universe.¹

Did Victorian scientists practice what they preached? For an answer, I consulted the complete works of John Strutt, later known as Lord Rayleigh, on the shelves of the Niels Bohr Library and Archives at the American Institute of Physics (AIP is the publisher of *PHYSICS TODAY*). In "On the theory of resonance," he described and analyzed his investigations into the acoustic resonances of pipes of various sizes and shapes.² Curiously, he cited cubic millimeters for the pipes' volumes but inches for their lengths. Kelvin also used inches on occasion. Perhaps the two physicists found inches more convenient.

I used to think that the US should join the rest of the world and adopt the metric system. Now, in light of Kelvin's and Rayleigh's undogmatic flexibility, I no longer do—because it doesn't much matter. US manufacturers already use metric, and it seems fine to keep measuring potatoes in pounds and gasoline in gallons.

References

1. S. Schaffer, in *Victorian Science in Context*, Bernard Lightman, ed., U. Chicago Press (1997), p. 439.
2. J. W. Strutt, *Philos. Trans. R. Soc. London* **161**, 77 (1871). PT