Weighty Matters

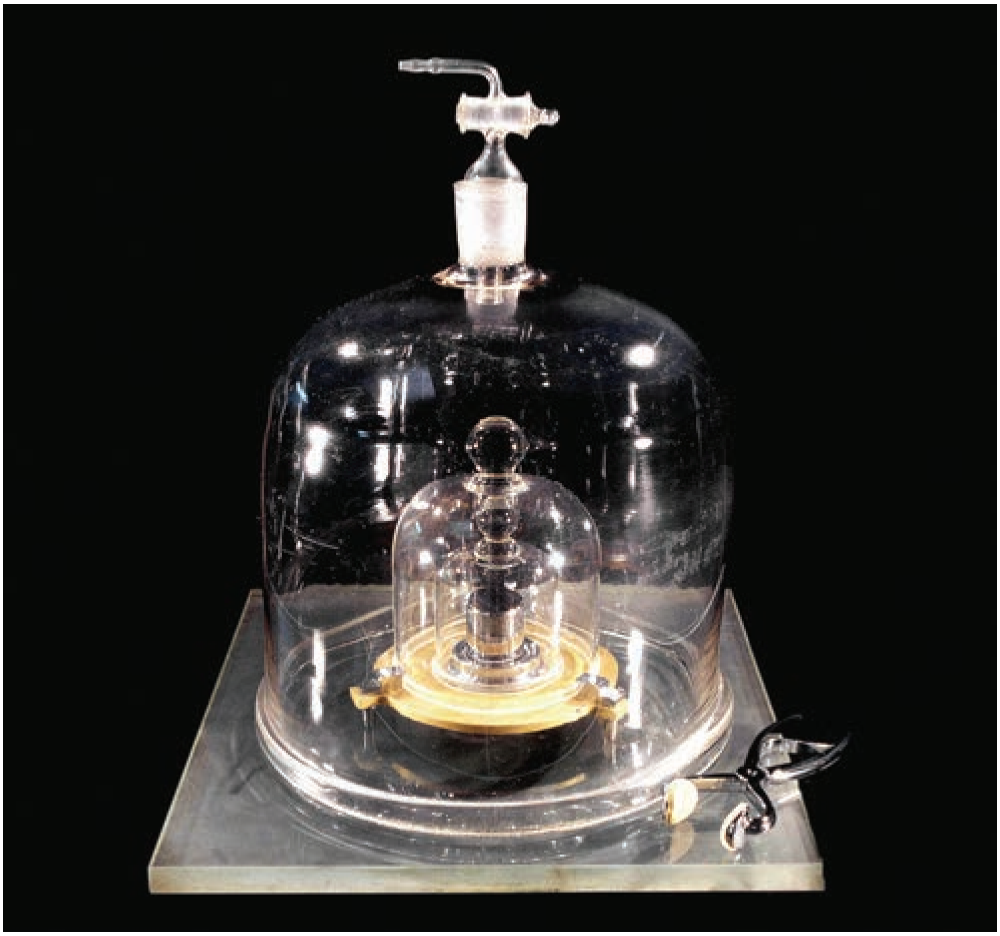
Mechanical engineer Jonathan Ellis is part of a quest to redefine the kilogram.

The kilogram is the last remaining measurement to be defined by a physical object: a cylinder of platinum and iridium held in a vault under three glass bell jars at the International Bureau of Weights and Measures (BIPM) in the suburbs of Paris. The international prototype, created in the 1880s and known familiarly as "Le Grand K," is the standard by which all other kilograms are measured.

But for all the vault-like protections, Le Grand K is vulnerable.

"The big joke is, if someone were to sneeze on the kilogram, there are about 10 fundamental constants that would change, because they're all tied to its value," says Jonathan Ellis, an assistant professor of optics and mechanical engineering and a specialist in metrology, or the study of measurements.

And it's not just a joke. Compared to official replicas held by other laboratories around the globe, Le Grand K is shrinking, albeit by just .05 milligrams in mass.



SAFE KEEPING: "Le Grand K," the original platinum and iridium cylinder that is still the international prototype for the kilogram weight, sits under three bell jars in the suburbs of Paris.

Established during the French Revolution by the French Academy of Sciences to standardize measurement, the seven basic units of measurement—the kilogram, the meter, the second, the ampere, the mole, the candela, and the kelvin—are now, with the exception of the kilogram, determined by what are called "realized standards," or procedure-based methods. "Instead of being tied to an artifact, you're tied to how you perform the measurement," Ellis says.

He and the members of his Rochester lab are involved in an effort to create such a procedure for the kilogram. They're contributors to a larger project being carried out by a group of national laboratories, including the BIPM and others from countries such as Denmark, Japan, Germany, and Australia. The lab representing the United States is the National Institute for Standards and Technology.

One effort to define the kilogram in terms of natural properties, begun in 1999, uses the watt balance, a device that defines mass by equating electrical and mechanical power. Ellis focuses his lab on how to make velocity measurements more accurate.

"When you use light to measure things, one of the limiting factors is the air," he says. "Light has to pass through the air, and air has turbulence." There are fluctuations in air pressure and in temperature. "For example, the human body will output about 100 watts of power, and so there will be a temperature gradient because you're standing near the instrument, and that will affect the light that passes through. We're talking about very, very, very small features and small distances"—on the atomic scale—"and so very small perturbations can cause a significant problem." Even someone talking in the lab creates disturbance, with sound pressure and the exhalation of carbon dioxide.

So Ellis is taking part in an effort to find a way to measure that—and to do so more quickly than a temperature sensor or a pressure sensor can manage.

The watt balance method isn't the only one under investigation. There is a competing method, called Avogadro's Sphere, in which scientists are trying to make a pure silicon sphere that has the number of atoms that would equal the mass of one kilogram.

"Both measurements in and of themselves are accurate, but they don't conform to each other," Ellis says. "There's some discrepancy there, and the international community is trying to figure out where, why, and how."

—Kathleen McGarvey

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