Critical Point Your favourite units

Deluged by responses to his request for your favourite units, Robert P Crease discovers that non-SI units persist, and are sometimes even popular, among the physics community.

Units are among the most intriguing features of science. They are the “bridges” between the empirical world of physical phenomena and the non-empirical abstract world of mathematics, allowing us to traffic back and forth. Once upon a time, many bridges of different varieties existed independently of each other. Over the years, the International Bureau of Weights and Measures (BIPM) has consolidated them into a single network, the “International System of Units” (SI).

SI is an elaborate convention consisting of seven base units — the metre, kilogram, second, ampere, kelvin, candela and mole — and numerous derived units, such as the hertz, volt, newton, coulomb, tesla and ohm, with still other units “accepted for use” within it, such as the tonne (10^3 kg) and day (86 400 s). These are all fully ingrained in the scientific world, yet some pre- and non-SI units persist outside and even inside the scientific world. In September 2009, I asked you to submit your favourite examples, and I received hundreds of replies.

Pre-SI units

Many pre-SI units arose directly out of everyday life. Consider those mentioned in Eric Cross’s novel The Tailor and Ansty, a book that gave such precise voice to Irish wit and poetry that it was banned the year after it was published in 1942. The book concerns a country tailor who is fond of relating the wisdom of the old Irish, that is, before “the people got too bloody smart and educed their ways of thinking for them”. Some of this wisdom involved units.

Land, the tailor announces, used to be reckoned in “collops”. The collop, based on the “carrying power” of land, “told you the value of a farm, not the size of it. An acre might be an acre of rock, but you know where you are with a collop”. One collop, for example, was the area needed to graze “one sow or two yearling heifers or six sheep or twelve goats or six geese and a gander”, while three collops were needed to graze a horse. The tailor complains of a neighbour’s boast of “four thousand acres – which sounds like a plantation, but the area only has “enough real land to graze four cows”. The tailor is surely exaggerating here (small surprise), for few people in his area own so much land, and it seems likely that 1000 acres in the west of Ireland, despite all its bogs and rocky hills, would be more than enough to serve the average cow. Nevertheless, his point is that a collop-measure cuts the neighbour’s boast down to size. “The devil be from me! But the people in the old days had sense.”

The old Irish also had a superior way of reckoning time, the basic unit of which was the lifespan of a ram, a type of small bird. The tailor then translates a list of units based on it: a hound outlives three rails; a horse outlives three hounds; a jock outlives three horses; a deer outlives three jocks; an eagle outlives three deer; a yew tree outlives three eagles; and an old ridge in the ground outlives three yew trees. There is no need to go further, for three times the age of the ridge is the age of the universe.

The tailor is wildly off (small surprise) in his estimate of the age of the universe, which is unlikely to be (lifetime of the rail) × 3^8. Still, his point is well made that the old Irish unit system may possess certain superiorities to ours in that it was “reckoned on the things a man could see about him, so that, wherever he was, he had an almanac”.

Physics World respondents gave numerous examples of similar pre-SI units derived from the world’s almanac. John Blake, a retired physicist and patent attorney living in Winchester in the UK, who spends several months a year in Spain, reported that the dia de bay (or “ox-day”) is still used in rural parts of Asturias in northern Spain. It refers to the amount of land a farmer can plough using an ox, which depends on soil and crop; a 50 ox-day plot of land (one day’s ploughing per week) is enough to give a farmer self-sufficiency for his family.

Other respondents liked the “chain”, that once-indispensable surveying tool invented in the 17th century. Equal to 22 yards, the chain has left its mark on everything from the cricket pitch (1 chain) and the definition of the acre (10 x 10 chains) to the length of countless city blocks. David Brandon from the Technion in Israel, meanwhile, was fond of the “firkin” — a wooden barrel that could hold nine imperial gallons, which just happened to be the quantity of beer needed to fuel parties back in his undergraduate days at Cambridge University. “Think about it: nine gallons or 72 pints [was] just about enough to keep 20 students happy until they were thrown out of college at midnight,” he explained.

SI and SI hybrids

Some readers, however, questioned the SI system itself. Indeed, as Jim Bogan, a retired physicist living near Eugene, Oregon, pointed out, units based on the CGS (centimetre–gram–second) system are still standard in astrophysics; stellar masses, for example, are often measured in grams. However, Bogan is no fan of CGS: it means that the Earth–Sun distance (1 astronomical unit or AU) is a ridiculous 15 000 giga-centimetres or 15 tera-centimetres, which requires two Greek prefixes. It would be more aesthetically pleasing, he proposed, to use the MGS (metre–gram–second) system, in which 1 AU is 150 giga-metres.

The MGS system would leave the Planck and gravitational constants unaffected – h = 6.625–31gm2 s–1, and G = 6.673–14m3 g–1 s–2 – changing only in order of magnitude. Electromagnetic units would also be unaffected in the MGS system, although electromagnetic units, like the Planck length, mass and time, would have to be rescaled. The plus of the MGS system is that it would unite the CGS and the MKS (metre–kilogram–second) system, which “has been a headache for physicists and their students for over a century”. But Bogan is not holding out much hope for things changing any time soon, because of what he dubs a “rigid adherence” to the SI force standard of the newton. “Trying to change this is like battling city hall,” he complained.

I posed this to Richard Davis, head of the BIPM’s mass section and a man wise in the ways of SI (and whose favourite non-SI unit is the perch for sentimental reasons; the deed to his former home in Washington, DC, gave the dimensions of the property in those units). Davis’s two-part answer explains why nearly all suggested improvements to SI are never quite as good as they seem. Part one is
historical: the SI system was built on the legacy of the decimal metric system in an attempt to maintain historical continuity as much as possible. Recognizing the formidable difficulty of changing measuring habits, SI took into account units that were in wide scientific use while tying up loose ends. This is the reason why one of the base units – the kilogram – contains a prefix, which otherwise does not seem to make much sense, though allowing this unit as an exception seems harmless.

The other part of the answer, Davis said, involves “coherence”, in the special meaning given this term by the “SI brochure”. “If you take any equation of physics, you can plug in SI values for all quantities and it automatically works as it should; that is, in a coherent system like SI, there is never a need to tack on additional constants that were not originally in the equation,” he said. The MGS system is not coherent, in Davis’s eyes. “Take everybody’s favourite equation: \( E = mc^2 \),” he explained. “If, on the right-hand side, I plug in mass in kilograms and the speed of light in metres per second, my result automatically appears in joules. But in the MGS, the Einstein relation would become \( E = km mc^2 \), where \( m \) is in grams, \( c \) is in metres per second, \( E \) is in joules and \( km \) is a conversion factor equal to \( 10^{-3} \text{ kg} \cdot \text{g}^{-1} \). Many of the bright ideas for reforming SI would lead to incoherence in this way.”

The requirement of coherence, Davis added, helped guide the way in which additional base units, such as the ampere and the kelvin, were introduced into SI. City hall has its reasons.

Thomas Yeung, from Suffolk in the UK, was one respondent who espoused the merits of the litre (\( 10^{-3} \text{ m}^3 \)) – another example of a non-SI unit that is “accepted for use”. (The coherent SI unit of volume is the m³, which has no special name. The litre is not a coherent SI unit because \( 1 \text{ L} = 10^{-3} \text{ m}^3 \), an equation containing an extra factor that does not equal one.) Indeed, Yeung measures his car’s petrol consumption in miles per litre, preferring it to the old miles per gallon because fuel in the UK is now usually priced by the litre. “I know it combines imperial and metric units,” Yeung explained, “but it’s easily understood (more miles per litre is better, fewer is worse). [It also] allows drivers to gauge how much fuel they need in litres to make a specific journey, and has a sensible scale, with normal cars having a value between 5 and 10.” The European measure of litres per 100 km, in contrast, indicates better efficiency with a lower number.

But the *Physics World* community also includes several die-hard and principled SI enthusiasts. Peter Main, an emeritus professor of physics at the University of York in the UK, told me that his son Andrew is an absolute SI fundamentalist who refuses to observe normal birthdays and instead measures his age in megaseconds. Andrew (a software engineer) admits that although the second is an astronomical accident – originally related to the rotational behaviour of the Earth – at least it is SI and is now defined without reference to the solar system. His father has taken on the spirit, if not the letter, of his son’s position by informing students that the length of each lecture is a “microcentury”, which corresponds to 52 minutes and 36 seconds.

**Off SI**

Many non-SI units have, however, survived. Gary Harper, an engineer stationed with the US military in Okinawa, Japan, cites the mil – an angular measure used worldwide – as an example of a non-SI unit that persists due to sheer practicality. Artillery personnel find it useful because a mil at a thousand yards or metres is about a yard or metre, “which makes it easy to adjust artillery fire”. Gil Ross liked the “nebule” – a unit minted in 1938 to measure visibility at night. It is a unit of obscuring power “such that 100 units reduce the intensity of light to 1/1000th part of its incident value”.

John Hearle, an emeritus professor of textile technology at the University of Manchester, liked the N/tex, a unit for specific stress, and claims in an appendix to the fourth edition of his book *Physical Properties of Textile Fibres* that it deserves a special name apart from its strict SI sibling, N kg m⁻¹. or its other names, psi/(in² cm) and BTU/ lb. Many physicists like “the barn” (\( 10^{-24} \text{ m}^2 \)), which is used widely in nuclear and high-energy physics to express the likelihood of one particle scattering off another and with its amusing origin during the Second World War to apply to the cross-section of uranium nuclei (“as big as a barn!”) that is a well-known part of physics lore. Its cousin is “the shed” (\( 10^{-24} \text{ barn} \)), Bryan Lovitz pointed out that the yoctometer, the smallest SI area unit, is 10,000 sheds.

Another class of non-SI units names the “least amount”. Andy Taylor, a retired instrument engineer, said that a “midge” was “the smallest amount of linear or rotational movement achievable at the output of a given mechanical or electrical device, within the constraints of static friction, the adjustment mechanisms provided by the designer and the dexterity of the operator”. Paul Wilby, a teacher in the East Midlands, liked the “gnat’s whisker” – a subdivision of that somewhat larger, well-known unit that, because *Physics World* is a family magazine, I’ll call a “gnat’s testicle”. Kevin Meyer, a physicist and software engineer from South Africa, explained the technical terms used to capture signals: a “tweak” is a fine-tune, a “twiddle” a gross manipulation and a “frob” an aimless manipulation.

**Off-off SI**

Yet another category of unit is light-hearted and of no practical value except for satirizing, spoofing or symbolizing the process of unit-making itself. The classic example of a
unit subjectively to measure an entirely subjective property, for instance, is the “helen”, named after the line in Christopher Marlowe’s *Doctor Faustus* referring to Helen of Troy’s face as having “launch’d a thousand ships”, implying the “millihelen” as the amount needed to launch one. Niki Walton insisted that the amount of breath needed to blow out candles on a child’s birthday cake is measured in “ant-farts”, while Tony Yule’s favourite units were the “cows” and “dogs” that his A-level physics teacher wrote on his graphs as axis titles when he had omitted them.

The classic example of an improvised unit named for a person is the “smooth”, after Oliver Smoot, a freshman at the Massachusetts Institute of Technology whose height was used to measure the length of the Massachusetts Avenue Bridge in 1958. But *Physics World* readers knew of others. At the annual sailing event of Bill Clay’s company, 0.01 knots is called a “rick” after an employee who is particularly adept at setting the sails to optimize the yacht’s performance. Alison Lees (née Procter) recalled an A-level biology class in which her class-mates were using uncalibrated electronic sensors to measure some quantity. Her protest against marking outputs in “arbitrary units” provoked a discussion on the nature of units — and the recording of the outputs in “proctors”.

Matthew Evans, meanwhile, claimed that his brother, who, like him, has a degree in physics from the University of Southampton, concocted a set of units based entirely on cruelty to moles: a mole of area is how thinly you can spread a mole before it explodes, a mole of length is the distance a deflating fully-inflated mole propels itself, a mole of area is how thinly you can spread a single SI-standard mole, and so on. “Purely theoretical,” Evans insists, lest the animal-rights organization PETA adds unit determination to its agenda.

As for Nigel Branson, he recalled how his physics teacher used to use the “Sanders Theatre cushion” as a unit of absorption. The teacher had in mind the story of how the US physicist Wallace Sabine, a pioneer of architectural acoustics, came up with a formula relating reverberation time to absorption, volume and surface area by experimenting with the seat cushions from Harvard University’s Sanders Theatre. Imprecise, perhaps, but it worked. Other improvised units used for estimation include the “Nelson’s Column” (for height), the “Sydney Harbour” (for volume) and *Physics World*’s own *bête noire* the “football field”, to describe the area of everything from solar power plants to telescope arrays, which last year drew criticism from certain readers.

### The critical point

Given that SI was designed to serve the needs of the scientific community (and, as much as possible, those of ordinary life) why do so many non-SI units continue to be used? SI is, after all, carefully supervised, maintained and continually improved, which makes it somewhat odd that some non-SI units seem so actively to resist SI. The reason, as the above contributions demonstrate, is that units serve human needs, and the needs of everyday life are diverse and continually changing.

Even satirical and silly units have a valuable function, for they bring to light the conventional character of units without forcing us through the trauma of a breakdown or transition. All this seems to confirm Gary Harper’s suspicion that, after having witnessed decades of changes in SI and non-SI units, the strongest human instinct does not involve survival, procreation or protection of the young, but “the desire to modify the current measurement system”. No doubt *Physics World* readers will continue to want to make their own changes.

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