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Avoid propagation of typos with numerical methods

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LETTERS TO THE EDITOR

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Neumann, but hold the von

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Dear Editor,

I am writing not to address an issue with AJP itself, but to point out a common misconception that has made its way into thousands of peer-reviewed publications, with the hope that this note will help prevent its propagation. The misconception involves the confusion of John von Neumann and Carl Neumann as the namesake of a type of boundary condition. A quick search on Google Scholar shows there are currently 1,170 publications that use "von Neumann boundary conditions," while the false-von rate on the Harvard/NASA ADS is approximately 8%.

The Neumann boundary conditions on the first derivative of a function (without von) are named after Carl Neumann (1832–1925), a German mathematician who worked on infinite series and developed an early model of electromagnetism. John von Neumann (1903–1957) was a Hungarian mathematician and polymath who emigrated to the United States and is known for his work on the theory of computation, several areas of physics, and the Manhattan project. While the work of von Neumann is better-known to physicists than that of Neumann, it is Neumann for whom the boundary conditions are named. While I cannot find any sources for or against the following claim, it is unlikely that the two are blood relatives.

There are similar but less common confusions in the literature between Hendrik Lorentz, best known for his relativistic factor, and Edward Lorenz, known for his contributions to chaos theory. Authors may take care to avoid misattributed references to "Lorenz contraction" or the "Lorentz attractor."

As I mentioned above, my goal in writing this is not to poke fun at authors who have made this error, but to educate future authors, referees, and editors who may be reading this and prevent the misconception from spreading further.

Avoid propagation of typos with numerical methods

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It is well known that incorrect information is often propagated over the internet. Physicists are not immune to this, and I would like to encourage my colleagues to take the time to check the information they post.

As an example, an internet search for the hydrogenic wave functions turned up many variants for the $n = 3$, $l = 1$ radial wave function. Two of these are

$$R_{31}(r) = \frac{4}{81\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2}\left(6\frac{Zr}{a_0} - \frac{Z^2r^2}{a_0^2}\right)e^{-Zr/3a_0}, \quad (1)$$

$$R_{31}(r) = \frac{4\sqrt{2}}{3}\left(\frac{Z}{3a_0}\right)^{3/2}\left(\frac{Zr}{a_0}\right)\left(1 - \frac{Zr}{6a_0}\right)e^{-Zr/3a_0}, \quad (2)$$

where the variables have their common meaning. What is interesting is that the second of these is exactly 3 times larger than the first. Hence, (at least) one of these is incorrect.

While it is possible to check the normalization integral by hand, it is even more straightforward to check the normalization numerically, using

$$\int_0^\infty r^2 R_{31}^2\, dr = 1 \approx \sum_{n=0}^{N} (n \cdot \Delta r)^2 \big(R_{31}(n \cdot \Delta r)\big)^2 \Delta r. \quad (3)$$

The numerical calculation can be done using virtually any programming language, or even a spreadsheet, and does not require a high level of precision. Equation (2) is found to be too large by a factor of 3. It is difficult to identify the original source of this particular error, since posted materials often lack citations, however the same error can be found in print form from at least 50 years ago. It is likely a simple typo that has continued to be propagated forward.

Unfortunately, this is not the only re-posted error I have run across. Numerical techniques provide a simple and expedient way to check correctness. In addition to normalization, simple numerical techniques can be useful to check, or at least spot check, summations, solutions to equations including differential equations, and many other mathematical results. Please check results before posting them.

Ball bearings and bearing balls

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Steel balls have been used for many years in various physics experiments and are almost universally described incorrectly by physicists as "ball bearings." It seems that physicists have chosen this term through common usage, without recognising that a ball bearing is actually a bearing rather than a ball. The bearing is constructed with an inner and outer race containing a number of steel balls that help to reduce friction by rolling around the race. The balls themselves are not ball bearings. Rather, they are bearing balls usually made of steel, but ceramic balls can also be used, allowing the bearing to spin faster since the balls are lighter. A common application is to support a wheel that rotates on an axle. Ball bearings can also be found in modern yo-yo's and fidget spinners.

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A cabinet of curiosities

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The photograph used on the front cover of the October 2020 issue of the journal, and its accompanying article,[1] showing its author Thomas B. Greenslade seated in the apparatus museum wing of his house in Gambier, Ohio, reminded me very much of the personal "cabinet of curiosities" of old. Though Greenslade's collection is far more orderly and organised than a traditional cabinet of curiosities, it stands as a wonderful collection of notable physics objects spared the ignominious fate of being dumped simply for being old. Who as a teacher of physics has not chanced across an old piece of equipment buried out of sight in their back room equipment store and wondered what it is, how does it work, and could it still be used?

In this connection, the story of the little known English amateur mathematician and astronomer Henry Perigal (1808–1898) is worth telling. He is a curious character from the second half of the nineteenth century. Labelled by the English mathematician Augustus de Morgan as a "paradoxer" for the strongly heterodox views he held regarding the lack of rotation of the moon about its axis as it orbited the earth,[2] Perigal is perhaps best remembered today for his elegant dissection proof he gave for Pythagoras' theorem.[3] In his own day, Perigal was largely recognised for his skill as an ornamental lathe turner and the beautiful and intricate curves he produced that were the result of various compound circular motions. As your archetypal Victorian scientific amateur his hobbies and interests could be described as being broadly geometric. Living to a great age, by his latter years his home had turned into his own private cabinet of curiosities. As one fortunate visitor recalled:[4]

> What a scene it was, that labyrinth of strange relics of science, the marvels of bow-pen lacework, the instruments covered up to keep the dust off, the Philosopher's simple couch in the corner all in view of these quaint things, and the Philosopher himself indefatigably squaring the circle or trisecting an angle, or proving that the world is all wrong about the moon. I don't know what it was that he was at then, but it was all like a leaf out of a book, wonderful and almost incredible. And the birthday album laid there with the autographs of all the high priests of science. What has become of it I wonder, and of the bow-pen work, and all the odd things strewn about in such profusion? I must write an account of it someday. It was exquisite.

It must have been a magical place to visit that has now all been lost. Here's hoping Greenslade's cabinet of curiosities is preserved for future generations to admire and enjoy.

[1]Thomas B. Greenslade, "Adventures with historical physics apparatus," Am. J. Phys. **88**(10), 864–870 (2020).
[2]Augustus de Morgan, *A Budget of Paradoxes* (Longmans, Green, and Co., London, 1872), pp. 261–262.
[3]Greg N. Frederickson, *Dissections: Plane and Fancy* (Cambridge U. P., Cambridge, 1997), pp. 30–31.
[4]Museum of the History of Science (UK), Manuscript Gabb 11, folio 56.