# LETTERS TO THE EDITOR

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## WHOSE GOLDEN RULE IS IT ANYWAY?

In an enlightening article,[1] Jackson writes that scientific discoveries more often than not are named after the wrong person. He provides ample evidence for this principle, dubbed "the zeroth theorem of the history of science," by giving a detailed description of several examples from physics.

To this list I would like to add another misattribution whose persistence has always struck me: in almost any textbook on quantum mechanics the treatment of time-dependent perturbations culminates in an expression for the transition probability per unit time between two states, which is then called "Fermi's Golden Rule."[2] In fact, in his classic text *Nuclear Physics*,[3] Fermi gives two results, one for first-order transitions and one for second-order transitions. He coins the names "Golden Rule #1" and "Golden Rule #2," but does not give a derivation. For this he refers to Schiff's textbook.[4] Clearly the names suggested by Fermi were hugely successful. So successful even that Schiff adopted this terminology in a later edition of his book,[5] in which he writes "Eq. (35.14)… is so useful that it was called 'Golden Rule No. 2' by E. Fermi." Nevertheless, Schiff was well aware that this formalism originated elsewhere. In another footnote he mentions its discoverer: Paul Dirac. More than 20 years before Fermi's book appeared, Dirac published a beautiful and comprehensive treatment of quantum mechanical perturbation theory[6] in which the first-order result is presented and applied to absorption and emission of radiation. In older texts, for example the book by Kramers[7] or that by Condon and Shortley,[8] Dirac is given full credit for his work. After Fermi published his book, that habit seems to have gone out of style. But Fermi is in no need of extra accolades; the key formula of perturbation theory is really *Dirac's Golden Rule*.


[1] J. D. Jackson, "Examples of the zeroth theorem of the history of science," Am. J. Phys. **76**(8), 704–719 (2008).
[2] One example out of at least a dozen such books is *Quantum Mechanics* by C. Cohen-Tannoudji, B. Diu, and F. Laloë (Wiley, New York, 1977).
[3] E. Fermi, *Nuclear Physics*, revised ed. (U. of Chicago, Chicago, 1950).
[4] L. I. Schiff, *Quantum Mechanics* (McGraw-Hill, New York, 1949).
[5] L. I. Schiff, *Quantum Mechanics*, 3rd ed., International Student Edition (McGraw-Hill Kogakusha, Tokyo, 1968). See footnotes on pp. 280 and 285.
[6] P. A. M. Dirac, "The quantum theory of the emission and absorption of radiation," Proc. R. Soc. London, Ser. A **114**, 243–265 (1927).
[7] H. A. Kramers, *Die Grundlagen der Quantentheorie* (Akademische Verlagsgesellschaft, Leipzig, 1938).
[8] E. U. Condon and G. H. Shortley, *The Theory of Atomic Spectra* (Cambridge U. P., Cambridge, 1951).



Taco D. Visser
*Delft University of Technology and VU University, Amsterdam, The Netherlands*


## +BOHREN'S EDITORIAL

Craig Bohren's guest editorial on errors in textbooks is characteristically incisive and correct.[1] What authors ought to do is clear, but many authors are too rushed to perform due diligence. Then how can we reduce the number of textbook errors in physics *per se* and, perhaps more numerously, in the history of physics? The key lies in one observation: textbook authors prefer to get it right.

Let me illustrate. One of my pet peeves is the treatment that introductory textbooks accord to Einstein's relation $E=mc^2$ and its implications. A few books get it right, but others present misleading or, worse yet, indefensible implications. Having helped a retired chemist to set his community on the road to a better conception of entropy, I decided to try his strategy. First, I published a substantial expository and historical article on $E=mc^2$. Then I read meticulously the relevant pages in the prominent current introductory textbooks and wrote each author a personal letter (with a reprint enclosed). Where I could praise, I did; where I could not, I offered suggestions. The response from authors was consistently positive.

Thus, if you want to see improvements and you know something about a topic, *write to the authors.*

The AJP may even find it productive to establish a clearinghouse for corrections, suggestions, and authors' addresses.


[1] C. F. Bohren, "Physics textbook writing: Medieval, monastic mimicry," Am. J. Phys., **77**(2), 101–103 (2009).



Ralph Baierlein
*Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011*


## REPEATED PROBLEM SOLVING REVISITED

The motivation of this Letter is to advocate the teaching of physics via strategies, which simultaneously incorporate the teaching of conceptual physics and quantitative mathematical reasoning. The pertinence of this concern is based on the observation that most of the recent published articles in *Physics Education Research* favors an emphasis on conceptual learning over quantitative reasoning. Thus, one might wonder whether the impact of this trend on students is that they fail to answer correctly quantitative questions involving simple standard computations. It is in physics courses where students are trained in using what they learned in their math classes, and even are trained in new nonstandard approaches to perform computations such as the use of dimensional analysis.

Accordingly, instructors should make a greater effort in teaching their students effective ways to approach the learning of physics, through strategies that integrate both conceptual physics and mathematical reasoning. In the long run, this will help to strengthen the ability of students to obtain physical insight, not only for the students but also for their instructors. Ideas based on problem-solving[1] strategies aimed at consolidating these two aspects in the teaching and learning of Physics have been advanced by Polya[2] and Reif.[3] Moreover, there is evidence showing the effectiveness of the aforementioned teaching approach as applied in active learning methodologies such as cooperative learning.[4]

[1] J. S. Rigden, “Problem-solving skill: What does it mean?,” Am. J. Phys. **55**, 877–877 (1987).

[2] G. Polya, *How to Solve It: A New Aspect of Mathematical Method*, 2nd ed. (Princeton U. P., Princeton, 1973).

[3] F. Reif, “Teaching problem solving—a scientific approach,” Phys. Teach. **19**, 310–316 (1981).

[4] P. Heller, R. Keith, and S. Anderson, “Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving,” Am. J. Phys. **6**, 627–636 (1992).

Sergio Rojas
*Physics Department,*
*Universidad Simón Bolívar, Venezuela*
*srojas@usb.ve*

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