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Øyvind Grøn and Arne Næss—Einstein's Theory: A Rigorous Introduction for the Mathematically Untrained, Springer, New York, Dordrecht, Heidelberg, London (2011)-ISBN 978-1-4614-0705-8 and David J. Griffiths—Revolutions in Twentieth-Century Physics Cambridge University Press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi, Mexico City (2013)-ISBN 978-1-107-60217-5

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Funding agencies, governmental departments, and universities typically sort the fields of knowledge into two broad categories: Hard sciences, on the one hand, and humanism and social sciences, on the other. For brevity, we will refer to the second class as the "social sciences," although we recognize the difference.

Within each category, a field is usually defined by the subject of its studies, but even contiguous domains are separated by deep trenches: different disciplines adopt conceptually distinct methods and approach the problems within their scopes from completely different viewpoints. In a recent article, Mazilu, Zamora, and Mazilu [*Eur. J. Phys.* 33, 793–803 (2012)] describe this divide in very clear language: "While simple, ideal models of complex systems are fundamental tools for physicists, molecular biologists are more detail oriented and descriptive in their research. Building simple models that capture the essence of physical phenomena is not an easy task; there is a fine line between an accurate model that is as simple as possible and an unrealistic model."

The breach separating the hard sciences from the social sciences is even more profound. As an illustration, we will share with the reader a story that goes back to the days before intelligence (IQ) tests were properly normalized. A human scientist commissioned to normalize the test for a certain district in Brazil tried a few quiz questions on a hard scientist, a friend of his. One of the questions was as follows: "Which animal among the following stands out as very different from the others, a cow, a camel, a duck, an elephant, or a horse?" The reader may not be aware of this, but even novice Portuguese speakers readily identify the word for cow, "vaca," with the feminine gender because it ends with the vowel "a." The words denoting the other listed animals belong to the masculine gender and, in the absence of explicit reference, are mentally associated with the males of the species. To the social scientist, therefore, it was obvious that "cow" was the correct answer.

The hard scientist, by contrast, had no trouble spotting the only bird in a group otherwise composed of quadruped herbivorous mammals. To him, clearly, "duck" was the right answer. One may conclude that it is not so easy to introduce geographic normalization for IQ tests when scientists from distinct areas of learning give different, acceptable answers to an apparently simple question, but this is beside our point. As silly as the narrative may sound, the gender–species quandary pinches the core of the difference between the schools of thought. At end of this review, in part to challenge physicists, we will tell another story concerning a problem in the social sciences. The suggested solution to that problem may surprise the reader.

We believe that it is time for physicists to try to explain their theories and methods to social scientists and for social

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scientists to explain their science to physicists. Explaining quantum mechanics and general relativity to social scientists is no cinch. Many efforts have been made to popularize physics with that public in mind; however, as Sir Arthur Eddington said in the 1920s, “Mathematical physics cannot be understood through popularizations. Mathematics plays a role that is not merely instrumental, like cobalt chemicals for the paintings of Rembrandt.”

The two books at the focus of this review try to explain physics to social scientists with proper respect for Mathematics.

Let us begin with the book by Grøn and Næss. Arne Næss was a philosopher who compelled Øyvind Grøn to write a book on general relativity, complete, and from scratch with all the necessary mathematics. He was unsatisfied with the popularized presentations of the theory and felt that he would have to dig deeper to really understand it. When the work was done, he added Arthur Eddington's quote to his preface to the book.

The text starts out by introducing vectors as oriented segments, then without saying that it is doing so explains differential calculus and differential geometry and goes on all the way to general relativity. It is difficult to say whether a social scientist unaided by a teacher can plow on from cover to cover, but physicists unfamiliar with Einstein's great theory will be able to work through the 14 chapters on their own.

Vectors are explained in Chapter 1. This chapter is well motivated, and we believe that the last page will be turned with a feeling that the profit was well worth the effort. Motivation is, of course, indispensable for skimming over symbols with pouted lips is a waste of time. Although it fares well in this respect, the opening chapter could be better motivated. The time-honored—some would say “traditional”—introduction to vectors states that “while certain physical quantities, such as temperature, mass, etc., can be specified by a single number, others, such as the velocity, need a direction. The latter are vectors.” This motivation is perhaps better than the approach in Chapter 1, but the authors cannot afford to use it. They must introduce as much geometry as possible and as early as possible, and so, they prefer a motivation that is purely geometrical and very elegant. The second chapter, on differential calculus, is rather complete. The following seven chapters explain differential geometry and are really very well written. In fact, they could constitute a short course on differential geometry.

The tenth chapter titled, “Conservation laws of classical mechanics,” is a crash course on classical fluid dynamics. This may strike the reader as a difficult subject, but we believe that anyone can understand Chapter 10, so clear is the presentation. In our experience, it is the appearance of equations that alarms people with limited mathematical training. However, given that the previous chapters have carefully removed this fear, fluid dynamics should not intimidate the reader. The next two chapters, 11 and 12, explain Einstein’s theory of gravitation, that is, general relativity and the explanation is superb. In fact, at the end of Chapter 12, the reader will surely ask himself/herself why relativity has never been explained this way before or how could he/she have thought it was so difficult. Finally, Chapter 13 applies the theory to certain well-known phenomena, and Chapter 14 introduces cosmology to nicely complete the book.

Only one tiny defect: the figure on page 239 showing the earth in the solar gravitational field and attributing the tides to its inhomogeneity is bound to attract questions like “Why is it that we have two tides a day?” Surely, the authors know the answer, but thought that it would distract the reader from the main line of argument.

This book will serve a social scientist very well, but only as a textbook. That is, we believe that one such reader will have to find a tutor. There is another public, however. Many physicists are innocent when it comes to general relativity or have passed the discipline with the minimum grade and now regret having forgotten everything. For them, the book will prove very useful and can be read without tutoring with great profit.

The second book that we want to review was written by David J. Griffiths. Readers familiar with the American Journal of Physics certainly know Griffiths and his efforts to make difficult material understandable to Physics students. Here, he addresses a different audience.

The book has five chapters. The first chapter explains basic physics from scratch. It begins with units and significant digits, then presents Newton’s law and ends with a section on waves. In other words, the first chapter covers the first 2 years of an engineering or physics course except for electromagnetism. Only the basic essentials, of course, but with enough substance to be of great help to social sciences and life sciences majors. The remaining four chapters cover the great breakthroughs of twentieth century physics. They explain special relativity, quantum mechanics, elementary particles, and cosmology.

The chapter on special relativity is very readable and has a section that—we know from experience in teaching special relativity—is illuminating: the section on paradoxes which helps the student to truly understand the kinematics of special relativity. After that, the chapter turns to relativistic dynamics and derives $E=mc^2$. It ends with a very nice discussion of the structure of space–time, which dissects Minkowski diagrams. The chapter is very readable and very well motivated.

The next chapter covers Quantum Mechanics. Professor Griffiths being the author of a very instructive, fun-to-read Quantum Mechanics textbook, the proximity to perfection in Chapter 3 is hardly surprising. We believe that it is within the reach of social scientists, but like Grøn and Næss’s work, it should be studied as a textbook with a tutor. The chapter comprises two parts: one covers the history of quantum mechanics and the other focuses on what quantum mechanics has to say about our world, an excellent chapter.

The fourth chapter is about elementary particles. It tells the history of the experiments that unveiled the particles and describes the theories that modern physicists have put together to explain their existence and multiplicity—there are so many particles! It fails to say that we know how to calculate almost nothing. Likewise, perhaps because the author was not intent on writing an encyclopedia, it fails to explain the theories that, in the reviewers' opinion, lead nowhere after having made bulky contributions to numerous volumes of very prestigious journals.

Library bookshelves house many such theories. Here, only the Analytic S-Matrix Theory of elementary particles will be mentioned, a beautiful formalism that has never been proven faulty, with which one of the reviewers has struggled. Like other propositions, the Analytic S-Matrix Theory appeals to mathematics that is simply too difficult to handle. Only senior scientists can recall it nowadays, with some trepidation.

The final chapter is on cosmology. This is another excellent piece, which ends with a discussion of general relativity. Needless to say, one page is insufficient to explain the material occupying 330 pages in the book first examined in this review.

In conclusion, we believe that Professor Griffiths's work constitutes an appropriate textbook for a Physics course targeting social scientists. True to its title, the book presents an enlivening account of the conquests that changed our view of the Universe in the twentieth century even though it leaves out a number of topics. The text barely touches on the physics of condensed matter for instance. Readers of a future edition might enjoy a chapter on the subject and its partnership with the gadgetry that has infiltrated our lives.

Finally, we would like to bring to our fellow physicists' attention a facet of Social Science research that we too often ignore. The social sciences have their own problems, which are interesting and very important in practice. Perhaps social scientists should make an effort to write books explaining their methods to us. To emphasize this point, here is an illustration that may puzzle physicists. We mention it to challenge colleagues and to show how the methods of physics can tunnel across interdisciplinary barriers.

Our example is from the Economic Theory, Micro-Macroeconomics, and comes from a book by Steven E. Landsburg, "The Armchair Economist." On page 60, we find the following problem: suppose that one day you drop a dollar bill in a sewer. Should you retrieve the bill or should you give up and leave it there? The solution should take into account that economists regard economic efficiency as a guide for personal conduct. It should also ignore the relative insignificance of one dollar in commercial transactions. Under these constraints, can the reader pick the correct answer between the two suggested alternatives?

Here is the solution offered to Landsburg by the ex-physicist David Friedman: if you retrieve the bill, you expend some effort, which costs money. You may, for example, have to pay someone to retrieve the bill. On the other hand, if you leave the bill to rot in the sewer, the money supply will shrink by one dollar. Now, [IF] the amount of goods and services in the economy remains unchanged notwithstanding the reduced currency stock, then the average price of goods shall drop by one dollar and you will lose nothing! Does the reader agree with this solution? We do not. The argument ignores a very basic physical notion, Le Chatelier's principle. We want to estimate the response of a system to changes induced by external forces. Le Chatelier directs our attention to the equilibrium point of that system. If the equilibrium shifts, the consequences can be very different from what one would naïvely expect.

We highlighted the [IF] that opens the exclamatory sentence in the previous paragraph because it is a large "if." The argument is flawed because the reduction in money supply upsets the economical balance. Is it not true that government changes the base interest rate to supply money to or drain money from the economy and control economic activity?

In the social sciences, even the variables describing the systems under study are difficult to define, and familiarity with the methods of Physics could perhaps be useful. Very few social scientists agree, which is why we should make an effort to explain our methods to them. The two reviewed books undertake this task with a great deal of success. They are triumphs in a world that seems to be in need of literature to bridge the gaps separating different intellectual upbringings, as illustrated by our two examples, and more thoroughly discussed in the aforementioned paper by Mazilu, Zamora, and Mazilu and in a more recent article by Dawn C. Meredith and Edward F. Redish [*Physics Today* 66(7), 38–43 (2013)].