Reasoning About Luck: probability and its uses in physics

Vinay Ambegaokar

231 pp. Cambridge U.P., New York, 1996.
Available from Cambridge University Press , Borders, and Barnes and Noble

Selected Reviews

Review from Am. J. Phys. 66 (8), August 1998
Written by Bill Sutherland,
Professor of Physics, University of Utah
© 1998 American Association of Physics Teachers

There are only a few really new ideas in physics; much of the rest is just recycling what has proven useful before. It is great fun introducing students to these new ideas, since they motivate themselves. But being truly new ideas, they do take some getting used to - lots of examples, repeated exposure with increasing sophistication. There simply is no substitute for time and maturity.

We all have our personal lists of the truly important and new ideas. My own list varies, but invariably includes the behavior of large systems: statistical mechanics and the existence of thermodynamics - what we might call thermal physics. And of all the new ideas one might cite, I have found that it is thermal physics that is most difficult for the novice. That is simply an empirical observation.

I have often wondered why this is so, and more importantly, need it be so? I have pretty much come to the conclusion that the problem is the way in which students are traditionally taught the subject - historical, but logically backward - so thermodynamics comes first, then classical kinetic theory, and finally quantum statistical mechanics. Now, thermodynamics is perhaps the most subtle discipline in physics, while classical statistical mechanics has its "paradoxes." By the time all is finally resolved with just a little quantum mechanics, many students are convinced the subject is not for them.

Let me make my point with a brief anecdote: In the 1930s Linus Pauling estimated the residual entropy of ice. I thought it would be a good qualifying exam question to ask the students how one might experimentally measure the residual entropy of ice, to check Pauling's estimate. The other members of the Exam Committee informed me that this question was nonsense, since only changes in entropy have any physical meaning. This in spite of the third law of thermodynamics, and the Boltzmann monument in Vienna with its famous inscription "S=k log W."

I hope by this overly long introduction to have convinced you that there is a real need for rethinking how we teach thermal physics - at all levels, but especially to undergraduates. Professor Ambegaokar has done just that, and given us an outstanding and ambitious textbook for nonscience majors.

In the nicely written Introduction, Professor Ambegaokar lays out for the student/reader his goals for the book. The tone is light, yet serious and without condescension. The unstated

assumption is that the reader is interested and intelligent, and that not being an expert is no limitation for the purpose at hand. To quote from his course description: "A course for inquiring nonscientists and nonmathematicians which will attempt to explain when and how natural scientists can cope rationally with chance. Starting from simple questions - such as how one decides if an event is 'likely,' unlikely,' or just incomprehensible - the course will attempt to reach an understanding of more subtle points: why it is, for example, that in large systems likely events can become overwhelmingly likely… ." There it is: the really new idea of thermal physics, than large systems behave differently and more simply.

I find Professor Ambegaokar's style throughout the book to be graceful and witty, with a nice balance of both encouragement and admonishment. The choice of topics is careful and economical, the level of presentation consistent. This is especially evident in the core chapters on probability, the law of large numbers, entropy and temperature, and thermodynamics.

I often teach a one-year course on modern physics - one semester of quantum mechanics and one semester of statistical mechanics - to the senior physics majors. There is always pressure to teach them to calculate, with the hope that understanding will follow. This is often just wishful thinking. I will use this book as supplementary reading, to sharpen their appreciation for probability, combinatorics, and the behavior of large numbers, without the distraction of mathematical technique. I realize that this is not the purpose for which this book was designed, but I believe it will serve the students well in the long run and will be well worth the time spent.

In any case, no one who has gone through this book would doubt that the residual entropy of ice has meaning, even though they might be unsure of exactly how to measure it. That is certainly progress.

Bill Sutherland is a Professor of Physics at the University of Utah. He does theoretical research on critical behavior and quantum many-body systems, especially exactly soluble models. He first taught thermal physics to undergraduates in 1970, when as a post-doc he took over Charles Kittle's course at Berkeley.

Review from Physics Today, December 1996
Written by Ruth H. Howes, Ball State University

Many physicists bemoan the public's ignorance of physics. Few invest time to consider what the public should know about physics. Vinay Ambegaokar has selected the basics of probability and its physical consequences as the key to public understanding - and as the basis of Reasoning About Luck, which he wrote as a text for a one-semester course for liberal arts students. Beginning with basic statistics and Newton's laws, he relates the molecular model of matter to macroscopic thermodynamics. He then discusses the direction of time and introduces chaos and quantum mechanics, basing the discussion on the fundamental principles of statistics and probability that he introduced at the beginning of the book.

Ambegaokar has correctly identified a major area of public ignorance: No one regularly

exposed to television and the other popular media can escape the proliferation of junk physics based on ignorance of the role of statistics in understanding the physical world. Chaos, thermal fluctuations and quantum mechanics are routinely used to justify phenomena ranging from psychic healing to ghosts. If students who are not majoring in science understood no more physics than that presented by Ambegaokar, they would have a solid basis for thinking about physics and the other sciences, as well as practice in constructing logical arguments.

Reasoning About Luck uses no mathematics beyond basic algebra and geometry. It is unusually well written, and the author's dry sense of humor considerably increased my pleasure in reading it. Examples early in the book range from baseball to planning a lobster dinner. At the end, the same basic ideas are used to discuss such ideas as why macroscopic events are not reversible in time even though they are based on physical laws that are completely time-reversible. The solved problems at the ends of the chapters provide a profusion of interesting paper-and-pencil activities. Unsolved problems would also have been helpful.

Although I thoroughly enjoyed reading this slim volume, I do not think that the typical student in a freshman physics course for nonscientists would find it equally appealing. The mathematics is well explained and basically simple, and the physical arguments are elegant and clearly presented. However, most freshman have never tried to think this way and would need more guidance than is provided here.

While unsuitable for a general liberal arts physics course, Reasoning About Luck would be a superb choice for an upper-division honors seminar aimed at students from all the sciences or as supplementary reading in an undergraduate course in modern physics. Many senior year physics students become adept at solving problems in thermodynamics without understanding the statistical basis of the subject. Ambegaokar's well-written, mathematically simple treatment would clearly benefit them. It is comparable to Richard Feynman's The Character of Physical Law (MIT Press, 1965), also aimed at liberal arts students, but very good reading as well for senior physics majors.

In thinking carefully about the minimum knowledge of physics that an educated citizen should have, Ambegaokar has made a real contribution to the discussion. In addition, he has produced a thoroughly enjoyable physics book.