Guesstimation

Solving the World's Problems on the Back of a Cocktail Napkin

Lawrence Weinstein and John A. Adam
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Back-of-the-envelope calculations are familiar to most physicists, who typically love to make order-of-magnitude estimates and are well prepared to do so. Physics teachers often encourage their students to develop such skills, which can be powerful aids for building understanding and for guiding research paths. Enrico Fermi was especially well known for making quick numerical estimates using minimal data. Thus questions such as "How many piano tuners are there in Chicago?" are commonly called Fermi questions. Outside the domain of physics, guesstimation skills can enhance understanding and decision making in business and government.

Lawrence Weinstein and John Adam's *Guesstimation: Solving the World's Problems on the Back of a Cocktail Napkin* is intended for a general audience. The authors assume that readers do not have the skills of working physicists, and they attempt to provide a general structure for solving estimation problems. Both authors teach at Old Dominion University in Norfolk, Virginia. Weinstein is a professor of physics who writes the column "Fermi Questions" in the *Physics Teacher*, a magazine published by the American Association of Physics Teachers; Adam, a professor of mathematics, is the author of *Mathematics in Nature: Modeling Patterns in the Natural World* (Princeton University Press, 2003).

Given its introductory level, *Guesstimation* has two potential attractions for a physicist: exposure to the clever techniques the authors use to provide order-of-magnitude estimates and a wide selection of fascinating questions. Numerical estimates are quickly obtained for questions that seem at first glance difficult or impossible to answer. Subtle and not-so-subtle humor punctuates the text, and I laughed out loud at times.

An impressive range of topics is covered, including energy and work, energy and environment, Earth and the Moon, the atmosphere, and risk analysis. The first two chapters, on problem solving and dealing with large numbers, can be skipped by scientists; on the other hand, I enjoyed reading them to learn the authors' views on some of the subtleties. Two appendices contain tables showing the lengths, areas, and masses of various small to large objects and the mass densities of materials. A lengthy list of unanswered questions is also available for readers who want to explore further.

The bulk of the book addresses specific questions such as "What is the surface area of a typical human?" The first page of each question contains a thought-provoking drawing by Patty Edwards, an art lecturer at Old Dominion, and gives hints that are printed upside down to deter readers from simply reading them before pondering the problem; a full solution is given on subsequent pages. The format encourages readers to work out each problem before looking at the authors' solution.

The geometric mean is used repeatedly and effectively to estimate numbers based solely on order-of-magnitude bounds. For example, to decide how long a 1.5-V battery will last, one might argue that it is likely to be more than 1 hour but less than 10 hours. The resulting geometric mean is $(1 \times 10)^{1/2} \approx 3$ hours. Some problems are worked in two distinct ways, giving answers of the same order of magnitude; answers to other problems are checked against known data. Such checks build confidence in the techniques used.

Guesstimation is generally well written, with few typos. The main attractions are its potpourri of interesting questions, the way the authors encourage readers to attack them, and the authors' resourcefulness in doing so. A departure from the authors' typically thorough approach is in their comparison of the power consumption of gerbils and humans, in which they miss the importance of the surface-to-volume ratio and the power per surface area. But such occurrences are few.

Although estimation techniques abound on the internet and are broached in many books, few books are devoted to numerical estimations per se. One that is directly physics related is *Back-of-the-Envelope Physics* (Johns Hopkins University Press, 2003) by Clifford Swartz (see the review in PHYSICS TODAY, May 2004, page 58). A more recent one is Douglas Hubbard's *How to Measure Anything: Finding the Value of "Intangibles" in Business* (Wiley, 2007). Although not a physics book, its content complements *Guesstimation*.

I recommend Weinstein and Adam's book to anyone who likes to do back-of-the-envelope calculations that address real-life issues. It can be particularly valuable for physics students, and it provides fun reading and thinking for a wide spectrum of readers.

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Equilibrium Between Phases of Matter

Phenomenology and Thermodynamics

H. A. J. Oonk and M. T. Calvet
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Harry A. J. Oonk and M. Teresa Calvet's *Equilibrium Between Phases of Matter: Phenomenology and Thermodynamics* is a welcome addition to the literature. The text will be useful to advanced undergraduates and first-year graduates who have had a solid course in physical chemistry and who want to extend their knowledge of phase diagrams and how those diagrams connect to thermodynamics. It will also be of value to more experienced practitioners who want to broaden their perspective. I have taught and done research on the thermodynamics and statistical mechanics of phase transitions and critical phenomena for more than 40 years; yet in reading through Oonk and Calvet's text, I have learned new things and relearned others that I had once known "in principle" but had not taught over the years.

The authors divide the book into three parts. The first presents a phenomenological overview of phase equilibria with a minimum of thermodynamic analysis. Results are introduced simply as facts. The second deals with formal thermodynamics and its application to phase diagrams in which the properties of solutions, particularly non-ideal solutions, do not play a significant role. The third part covers the thermodynamics of solutions and is developed in some detail. The authors consider partial molar quantities and composition dependence of chemical potentials, and they explore the consequences of those concepts for phase diagrams. Extensive problems and their detailed solutions are a solid asset. I worked through several and found