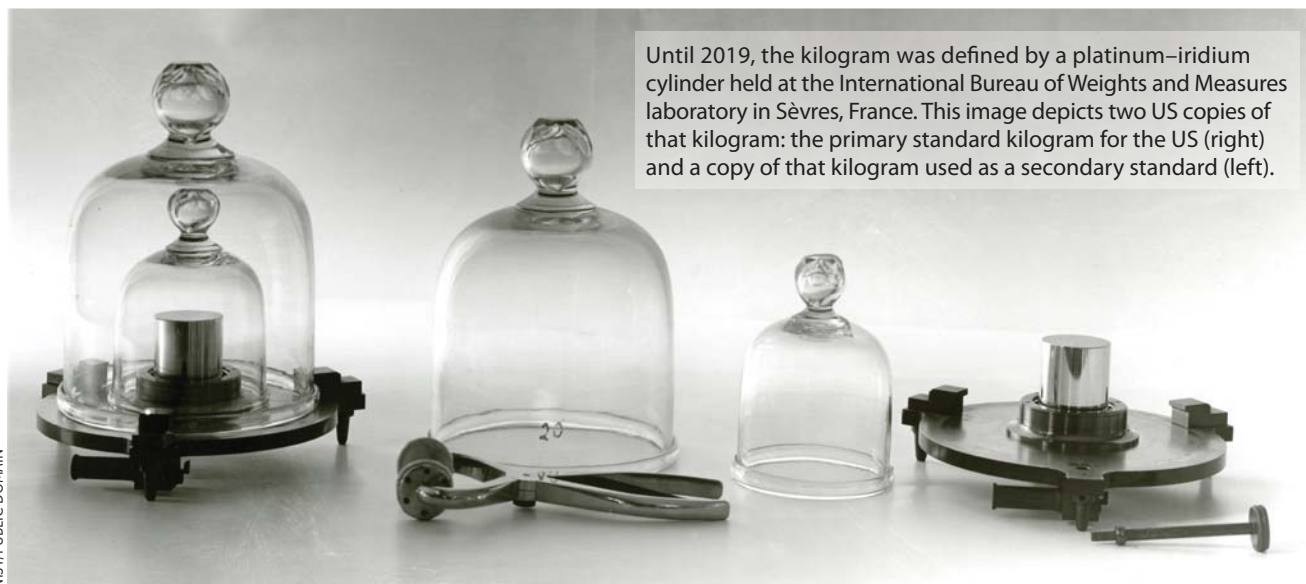




Until 2019, the kilogram was defined by a platinum-iridium cylinder held at the International Bureau of Weights and Measures laboratory in Sèvres, France. This image depicts two US copies of that kilogram: the primary standard kilogram for the US (right) and a copy of that kilogram used as a secondary standard (left).

The deeper power of dimensional analysis

In the preface of his new book *Fundamentals of Dimensional Analysis: Theory and Applications in Metallurgy*, Alberto Conejo notes that the “full potential” of dimensional analysis will always be circumscribed if it is introduced solely “as a tool to reduce the number of variables.” That sentiment will undoubtedly ring true for all physicists who teach or use scaling and dimensional analysis daily to produce profound insights. *Fundamentals of Dimensional Analysis* purports to demonstrate the deep power of those methods in metallurgical applications.

Chapter 1 provides a terse overview of the significance of dimensional homogeneity and the power of dimensional analysis. Chapter 2 traces the origins of that approach by detailing the early ideas of Galileo Galilei, James Clerk Maxwell, and others. The third chapter offers a quick tutorial on the history of units from antiquity to the present day. It also outlines how the standard meter, kilogram, and other SI base units have gradually evolved over time (see the article by David Newell, *PHYSICS TODAY*, July 2014, page 35). Conejo ends that chapter by discussing dimensional homogeneity, or the so-called fruit-salad law—as the saying goes, “You can’t add apples and oranges unless you want fruit salad.”

Familiar dimensionless quantities like the Reynolds, Prandtl, and Froude numbers, which are encountered in transfer processes, are introduced in chapter 4. Although other books contain more com-

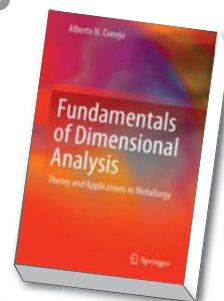
plete lists of those dimensionless numbers, that chapter does contain interesting brief biographies of the scientists associated with those quantities. Conejo then outlines the various methods to deduce relevant dimensionless groups in a given situation. He discusses the familiar Rayleigh method in chapter 5, but for some strange reason, it is only in chapter 6 that he introduces the formalized version of the method known as Buckingham’s theorem, which determines the number of dimensionless parameters to expect in a given application.

Chapters 7–9 expose readers to the Ipsen, matrix, and inspection methods of dimensional analysis. Those techniques are not mutually exclusive, so it is unfortunate that Conejo doesn’t elucidate the connections between them. That could easily confuse uninitiated readers. On the plus side, he uses the same example of heat transfer from a sphere in each of those chapters to illustrate different methods of extracting dimensionless numbers.

Chapters 10 and 11 explain how experimental results must be combined with dimensional analysis to establish quantitative relationships between dependent and independent variables that can be used for predictive purposes. In chapter 10 he uses a gas bubble rising in a quiescent liquid as the model flow, alongside a few other familiar examples. The bubble’s shape, Conejo notes, is determined by a balance among the inertial, viscous, and surface-tension forces. Chapter 11, on

Fundamentals of Dimensional Analysis Theory and Applications in Metallurgy

Alberto N. Conejo
Springer, 2021. \$139.99



the other hand, concentrates exclusively on modeling metallurgical operations like slag foaming, bubbles, and gas injection in steelmaking. Some of the discussion in that chapter—which, at almost 200 pages long, makes up more than half the book!—develops valuable insights by prudently blending dimensional analysis with available experimental data.

Chapter 12 addresses the issues dealing with the similarity (geometric, dynamic, kinematic) and scale-up of lab-scale data. The 13th and final chapter deals mainly with the scaling of the familiar Navier–Stokes and energy equations used to describe the flow of Newtonian fluids, a topic covered in many other books.

Even though the book’s title includes the words “fundamentals” and “theory,” it is more of a “how-to” book. For that reason, aside from some examples from the discussion of metallurgical nonreacting systems in chapter 11, it is likely to be of limited interest to both students and practitioners of dimensional analysis.

Strange inconsistencies and omissions

hamper the book. When Conejo considers the flow through a tube, for example, he does not include the fluid density ρ in one list of pertinent variables early in the book but adds it to a similar list later without any explanation. Similarly, in the chapter on Buckingham's theorem, Conejo does not mention that one of the requirements when selecting repeating variables is that a subgroup should not be able to form a dimensionless group. Another serious omission is the lack of discussion of chemical and material similarity in chemical reactions encountered frequently in metallurgical processes.

Several typos also slipped through the cracks. At one point, for example, Conejo mentions the physicist Osborne Reynolds when he surely means Lord Rayleigh. Later in the book, the discussion of the Navier–Stokes equations contains several errors: The x -component of the equations should contain g_x and not g , the expression for the so-called total deriva-

tive is incorrect, and no distinction is made between scalar and vector quantities. Neither the equations nor the tables presented in the book are numbered, which makes it rather tedious to read.

Fundamentals of Dimensional Analysis is a curious book. It isn't a textbook, but neither does it present the state of the art in dimensional analysis. For that reason, it isn't clear who its target audience is. But the book does contain some interesting and novel applications of dimensional analysis (although similar works do too), and the historical sections at the beginning of most of the chapters are effective. On those counts, it is a worthwhile addition to the existing literature. But I continue to prefer other books on the subject like Don Lemons's 2017 textbook *A Student's Guide to Dimensional Analysis*.

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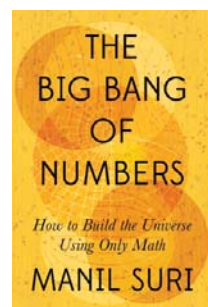
NEW BOOKS & MEDIA

Good Night Oppy

Ryan White

Prime Video, 2022

During the 1990s, NASA lost three Mars missions: *Mars Observer*, *Mars Climate Orbiter*, and *Mars Polar Lander*. So a lot was riding on the rovers *Spirit* and *Opportunity* when they launched in 2003. Originally intended to survive 90 Martian days on the planet's surface, both rovers remained active for years: *Spirit* until 2011 and *Opportunity*, remarkably, until 2018. In *Good Night Oppy*, the director, Ryan White, uses archival footage, interviews, and artistic renderings to compose a love letter to *Opportunity* and the scientists and engineers who worked on it. It's touching to see how attached the NASA team became to *Opportunity*, which overcame dust storms to reach Endeavour Crater after a three-year trek. Although the film falls firmly in the inspirational-documentary genre, it is a fun watch. —RD



The Big Bang of Numbers

How to Build the Universe Using Only Math

Manil Suri

W. W. Norton, 2022. \$32.50

Inspired by the popularity of his 2013 *New York Times* opinion piece, "How to fall in love with math," the mathematics professor Manil Suri has expanded on the topic of math appreciation with *The Big Bang of Numbers*. Aimed at math novices and enthusiasts alike, the book begins with the titular Big Bang, an "origins" story in which Suri shows how to create math's basic building blocks—numbers—out of nothing. He then goes on to discuss how those numbers can be used to devise arithmetic, geometry, algebra, and physics, and ultimately to construct the entire universe. By limiting the formulas and equations, the author has created a very readable tour of mathematics that emphasizes ideas over calculation.

—CC PT



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We seek experimental candidates in quantum matter and quantum information, including quantum and low-dimensional materials, materials with strong electronic correlations, cold atoms, quantum optics, and quantum enabled technologies. We also seek theoretical candidates in condensed matter theory, statistical physics, neural networks or data analytics.

Appointees are expected to assume teaching responsibilities for undergraduate and graduate courses, and to conduct vigorous research programs. Further information about the Department is available at <http://physics.ust.hk>.

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Application Procedure: Applicants should submit their application including CV, cover letter, complete publication list, research statement, teaching statement, and three reference letters, via **AcademicJobsOnline.org** at:

<https://academicjobsonline.org/ajob/jobs/16290>

Please quote reference number "PHYS2509" in your application materials.

Screening of applications begins immediately, and will continue until the positions are filled.