Book Reviews

Edited by Volker H. Schulz

Principles and Applications of Dimensional Analysis and Similarity. *By Sandro G. Longo*. Springer, Cham, 2021. $84.99. xxxi+428 pp., hardcover. ISBN 978-3-030-79216-9.

Readers of *SIAM Review* need no reminder of the value of mathematical models. These are the basis on which we can make quantitative predictions of the world around us. However, in order for us to obtain useful conclusions, the mathematical analysis of a model need not be quantitative. Starting from assumptions based on physical observations, we can perform a qualitative analysis, compartmentalizing different types of quantities (e.g., lengths versus masses), and invoking consistency-type conditions. This allows us to identify combinations of system parameters, such as the Rayleigh number in fluid dynamics, that convey critical information for how the system will evolve. Such dimensional analysis also reveals how systems can be expected to behave at different scales, allowing us to use physical models for testing and design before building an expensive full-scale prototype.

Despite the obvious applications to fluids, I've always found this subject rather dry; but Longo's book brings it to life! The material is developed in conjugation with a countless array of cute examples, each roughly a page in length, that highlight the utility of the methodology in diverse areas of application. These examples grow seamlessly from simple (e.g., Pythagoras' theorem and the motion of a ball on a ramp) to complex (e.g., aquaplaning, shock waves produced by explosions, and the Weissenberg effect whereby a non-Newtonian fluid is able to climb a spinning rod). These reminded me of Mark Levi's long-running "Mathematical Curiosities" column in SIAM News (https://www.marklevimath.com/sinews), which has a similar mindset.

The book covers a lot without feeling long. It starts with an accessible introduction to clarify the basic concepts of units, dimensions, and the novel notation that is involved. It explains the principle of dimensional homogeneity, Rayleigh's method for the matching exponents in a dimensional equation, and Buckingham's theorem for dimensionless groups, and proceeds to more advanced techniques on functions of dimensionless groups and dynamic similarity. The latter part of the book looks in detail at particular systems, including centrifuges, wind tunnels, river hydraulics, sediment transport, and the deformations of rigid structures. The book is comprehensive and clear, with many nice diagrams, and uses the same methodology and notation throughout the book, which is very helpful.

I liked how the material is developed in a heavily mathematical framework. Fundamental quantities (length, mass, etc.) are treated as basis vectors, and the analysis is performed in the context of linear and abstract algebra. Yet there did not seem to be any unnecessary mathematical abstraction; the connection to physical reality was ever present.

As you can tell, I really enjoyed this book. The writing is clear and eloquent, and it was fun to see a wide range of fundamental physical principles derived in a concise manner. The book is substantial with a wide scope, so should be valuable to many.

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