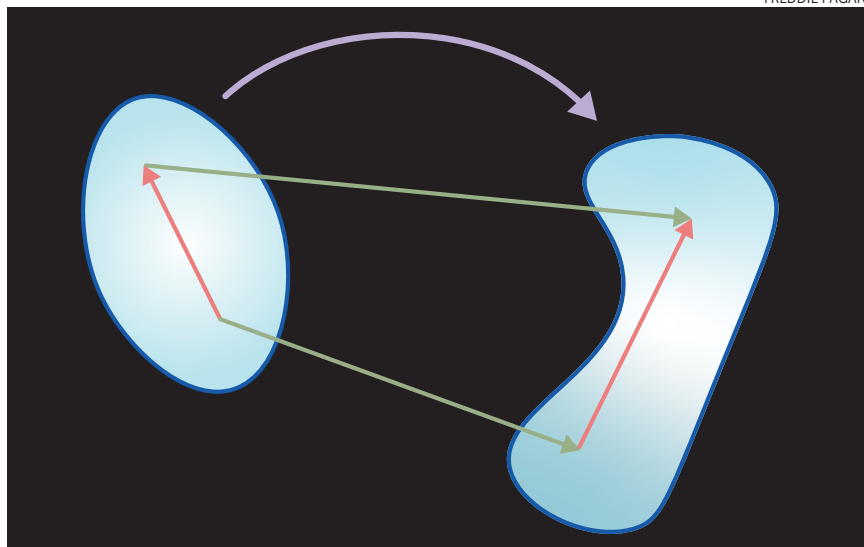




A quick reference for continuum mechanics

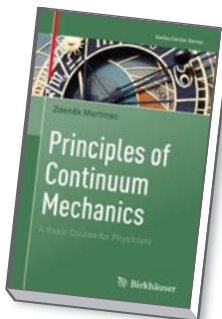
Continuum mechanics, arguably the crown jewel of classical physics, is a framework for modeling arbitrary material deformations that are subject to constraints for a motion to be physically possible. A course in continuum mechanics might be an undergraduate's first exposure to tensor analysis and analytical geometry, so a text for such a course requires plentiful figures, in-text examples, and end-of-chapter exercises. *Principles of Continuum Mechanics: A Basic Course for Physicists* by Zdeněk Martinec lacks those crucial components and therefore is best regarded as a quick reference for mathematically adept readers who are already familiar with the subject. For that audience, the book is useful and content rich.

As is typical of continuum mechanics treatises, *Principles of Continuum Mechanics* mentions only the general character of laboratory data. The book omits any discussion of the spatial scale at which discrete components can be well modeled as a continuum; instead, it focuses on formulations unified in the 1950s and 1960s by Clifford Truesdell, Walter Noll, Bernard Coleman, Morton Gurtin, Ahmed Eringen, and their contemporaries.

Rather than starting with the customary chapter on tensor notation, *Principles of Continuum Mechanics* opens by employing multivariate mappings to describe the time-varying deformation of a

Principles of Continuum Mechanics A Basic Course for Physicists

Zdeněk Martinec
Birkhäuser/Springer,
2019. \$49.99 (paper)



body from one geometrical configuration to another. The book proceeds at breakneck pace, and it often uses terms or symbols before they are defined. Topics include large-deformation kinematics, field equations, and a better-than-average description of contemporary entropy principles and linearization with prestress. Constraints and expectations applicable to all constitutive models are discussed, and some specific models are presented. Although the book offers below-average instruction on Cartesian tensor analysis, it does include appendices on curvilinear surface geometry and orthogonal curvilinear coordinates.

Principles of Continuum Mechanics is mostly error free and fastidiously rigorous, with some unfortunate exceptions. The book's discussion of mappings, for example, perpetuates the myth that having local invertibility—a positive Jacobian—at every point ensures global invertibility of a deformation mapping. If

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that were true, finite-element codes wouldn't need contact detection schemes to prevent nonphysical material interpenetration. The book often invokes smallness of a physical quantity without stating a standard of comparison; it even nonsensically asserts the smallness of stress, a dimensional quantity, in comparison to unity, a dimensionless quantity.

Rigor, elegance, and clarity fall short in some respects. Mass is incorrectly referred to as an intrinsic property of a body. After stating that "an arbitrary non-singular tensor T is positive definite if $\vec{v} \cdot T \cdot \vec{v} > 0$ for all vectors $\vec{v} \neq 0$," the book goes on to spread the myth that positive eigenvalues of T are sufficient for T to be positive definite; the 2×2 matrix $T = \{\{4,9\},\{1,4\}\}$ with $\vec{v} = \{1,-1\}$ is a counterexample. One of the book's proofs invokes positive definiteness of a decidedly nonpositive definite tensor, strain. The book refers to "Lagrangian" and "Eulerian" variables, potentially confusing word choices that fail to emphasize the distinction between a tensor and the tensor's various functional representations.

When presented with the equations

of thermodynamics, readers will ask—but not find answers to—some reasonable questions: What exactly is energy? What is temperature? Heat? Entropy? What motivates or proves their existence? Although the equations of thermodynamics are properly stated and analyzed, explanations of their physical interpretations are absent, weak, or wrong. For example, radioactive decay and chemical reactions are incorrectly cited as examples of heat supply in the first and second laws. There is no discussion of the role of internal variables, such as plastic work or chemical species fractions, as additional independent variables in the energy potential function.

The book has a few unexpected omissions and questionable choices in terminology. For example, Martinec claims the phrase "small deformation" means "small displacement gradients," which is misleading because the two are not equivalent. The book also refers to the symmetric part of the spatial velocity gradient as "the strain rate" even though it is not the rate of any path-independent function of the deformation gradient. More broadly, the book needs stronger emphasis on the

distinction between state variables and path-dependent variables.

Martinec does not offer a satisfying definition of objectivity; some tensors are confusingly identified as being scalars or vectors. The concept of fundamental potentials is not mentioned, nor is the role of different thermal constraints in purely mechanical constitutive models. Lie rates, which are common in finite-element codes, are not discussed. The book's index is missing entries for corotational, curl (and "rot," a nonstandard abbreviation for curl), deviator, double dot, isotropy, Newtonian fluid, objectivity, and other key terms.

Many books on the subject share the shortcomings of *Principles of Continuum Mechanics*. The book might therefore be seen as a retelling of an old story, one that does not address fundamental gaps or the need for clarity in the existing literature. *Principles of Continuum Mechanics* can nevertheless serve as a useful quick-reference summary of major results and analysis methods in continuum mechanics.

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NEW BOOKS & MEDIA

Cracking the Digital Ceiling

Women in Computing Around the World

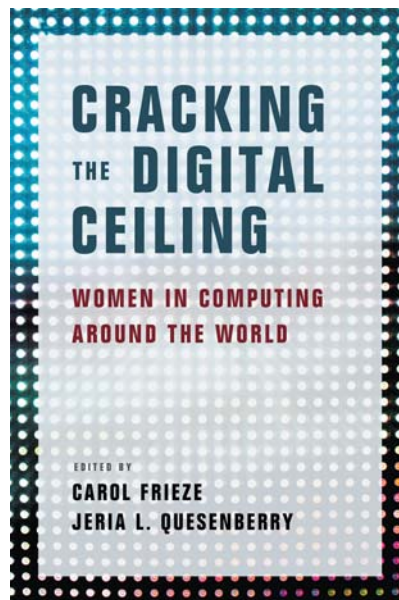
Carol Frieze and

Jeria L. Quesenberry, eds.

Cambridge U. Press, 2019. \$29.99 (paper)

Cracking the Digital Ceiling addresses the stereotype that women are intellectually inferior in the field of computer science. Editors Carol Frieze and Jeria Quesenberry collected perspectives from experts across the globe to show how culture and social constructions shape people's view of women's capabilities. For example, the chapter on education in Israel reports that women face strong work-family conflicts that men do not. Women in different cultures and countries face that problem too, and other factors, including unbalanced institutional support and the culture of startup companies, also affect their participation. The editors argue that the problem's complexity precludes simple solutions: Local and global remedies will need to be implemented in tandem so more women are welcomed into the field of computer science.

—AL



The Little Book of Cosmology

Lyman Page

Princeton U. Press,
2020. \$19.95

At just 152 pages, including appendixes and the index, *The Little Book of Cosmology*

covers a lot of ground in a relatively short space. Aimed at readers with some knowledge of physics concepts, the primer starts off with a few basics about the cosmos, including the size and age of the universe, and then moves to such topics as its composition and evolution, the cosmic microwave background, matter and dark matter, and the cosmological constant. All those components come into play in a chapter on the standard model of Big Bang cosmology. The author, observational cosmologist Lyman Page, tops off the discussion with some intriguing questions yet to be answered, such as whether the cosmological constant is really constant.

—CC

