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Book Review

Theory of Dislocations, Third Edition, by Peter M. Anderson, John P. Hirth, and Jens Lothe, Cambridge University Press, 2017. ISBN 978-0-521-86436-7

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For nearly 60 years, the book "Theory of Dislocations" by John P. Hirth and Jens Lothe has been the authoritative reference on the theory of dislocations. The reputation of the book was that it was not for the feint of heart. Rather, it was widely considered to be the authoritative reference to be consulted only after the reader had started with more elementary books on dislocations like "Introduction to Dislocations" by Derek Hull and David J. Bacon or "Elementary Dislocation Theory" by Johannes and Julia R. Weertman. More recently, the book by Wei Cai and William D. Nix, "Imperfections in Crystalline Solids" has provided an intermediate introduction to dislocations as a bridge between the more elementary books just cited and the book by Hirth and Lothe, which was written for experienced researchers. Now, with the Third Edition of "Theory of Dislocations," with Peter M. Anderson as the lead author, the classic book by Hirth and Lothe has been made much more assessable to a wider audience of students and researchers. Without sacrificing any of the rigor found in the first two editions of "Theory of Dislocations," the Third Edition provides a much more tutorial approach to understanding and appreciating the theory of dislocations.

The subjects covered in the Third Edition are largely the same as those in the previous editions, with each of the 23 chapters in the Third Edition matching the same 23 chapters in the previous editions. But the developments and derivations in each chapter are explained in much more detail, often with equations that were presented in contracted notation in previous editions written out, term by term, in the Third Edition. This makes it easier for less experienced students to follow the developments. Some very nice features of the Third Edition are the one-page research highlights that appear at the beginning of each chapter, illustrating some aspect of the developments in that chapter. Each chapter also begins with a summary of the key developments of that chapter in the form of important quantities or relationships that are referenced to the pages or equation numbers where they are found in that chapter. This feature provides a handy table showing where to find those findings in that chapter.

The chapters themselves include greatly expanded and improved illustrations that provide much more detail and make it much easier for the inexperienced student to understand the developments. In addition, handy notes are included on the sidebars of each page, as a quick reminder of the content on those pages. Although references to original works are still included in the text, the references themselves no longer appear at the bottom of the pages on which the citations appear. Instead they are listed in alphabetical order on 28 pages at the back of the book. This serves to make the book much more uncluttered and readable. In addition, a complete set of worked solutions and supporting MATLAB codes for the problems at the end of each chapter, a set of Powerpoint files containing all figures in the book and Errata are all available at the Cambridge University Press website for the book, under the Resources tab.

While all of the fundamental developments and relations in the previous editions of the book are retained in the Third Edition, several new or recently popularized developments of the theory of dislocations are now included in some of the chapters, especially with respect to computing the properties and behavior of dislocations. In Chapter 1, covering the basic geometry of dislocations, there now appears a treatment of the tensorial nature of the dislocation density and the connection to lattice curvature, which has attracted recent attention. In Chapter 2, on elasticity, Green's functions for elastic displacements that were given for continuum solids in the earlier editions have been extended to discrete lattices, allowing for the solution of problems in discrete lattices that may be anisotropic. Chapter 2 also includes a fuller account of the interaction between external and internal stresses in elastic solids and provides more detail on the relationships that describe these interactions.

Chapter 3 on the theory of straight dislocations now includes a treatment of mixed dislocations and their interactions with free surfaces, reflecting recent interest in the behavior of dislocations in thin films and other nanostructured materials where free surfaces play an important role. That chapter also now includes a treatment of conserved integrals that are useful in computing the forces on, and energies of, dislocations. Chapter 5, Applications to Dislocation Interactions, includes a treatment of multipole expansions, greatly improving the efficiency with which the interactions of large numbers of dislocations can be computed.

The field of discrete dislocation dynamics (DDD) simulations was developed and has flourished since the second edition of "Theory of Dislocations" was published in the early 1980s. So, an introduction to that subject is now given in Chapter 22 on Dislocation Interactions and Barriers.

While the Third Edition of "Theory of Dislocations" has been much improved and made more accessible to a larger number of students and researchers, it is still not a beginning book on this subject. But after starting with the elementary and intermediate level books cited above, a student or beginning researcher can now much more easily utilize the advanced formulations that have always been available in "Theory of Dislocations." The fine hand of Peter M. Anderson, the lead author of the Third Edition and one of the great teachers of this subject, is seen throughout the book.

