Seismic Wave Theory
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Seismic Wave Theory
Edward S. Krebes


Professor Krebes’s “Seismic Wave Theory” is highly recommended for students, lecturers and practitioners of seismology, as well as related disciplines. The theoretical aspect of this book is particularly important because seismology cannot exist without a theory that mediates between models and data; measurements alone do not provide information about the Earth interior, which—without a theory—is not accessible to us.

The book consists of 350 pages and ten chapters, namely, 1: Vectors, Tensors, and Fourier Transforms; 2: Stress, Strain, and Seismic Waves; 3: Reflection and Transmission of Plane Waves; 4: Surface Waves, Head Waves, and Normal Modes; 5: Waves in Heterogeneous Media; 6: Data Transformations; 7: Synthetic Seismograms; 8: Seismic Migration; 9: Plane Waves in Anisotropic Media; 10: Plane Waves in Anelastic Media. Each chapter has numerous exercises, with a selection of answers provided at the end of the book under Answers to Selected Exercises. For instance, the first chapter has thirty-one exercises, and nine among them have solutions. Several chapters have appendixes. There is Appendix 1A: General rotation with Euler angles and Appendix 1B: The Convolution of Continuous Functions; Appendix 2A: Apparent Velocities; Appendix 5A: Acoustic Wave Equations for Heterogeneous Media and Appendix 5B: Eikonal, Transport, and Wave Equations; Appendix 7A: Synthetic Shot Records and Wavefronts; and Appendix 9A: Velocities, Elliptical Anisotropy, Slowness.

“Seismic Wave Theory” requires a background in mathematics that—for senior undergraduates and first-year graduate students in geophysics, physics, mathematics, or engineering—should not be a limiting factor. Moreover, the chapter on “Vectors, Tensors, and Fourier Transforms” helps the readers to acquire or review this background.

Chapter 1 is a brief introduction to mathematical operations in three-dimensional space. The majority of this chapter should—for most readers—be a reminder of a standard vector-calculus course. Various products appear therein, namely, the dot, cross, and triple product, as well as various spatial derivatives, namely, the gradient, divergence, curl, Laplacian, Jacobian, and directional derivative. Different coordinate systems, including curvilinear coordinates, are allowed to rotate and translate, permitting a presentation of the concept of the corresponding invariances. The chapter concludes with an introduction to the Fourier analysis. The emphasis of this chapter is on algebraic rather than fundamental issues; thus, a vector is presented in terms of explicit Cartesian coordinates rather than as an abstract entity. Brief as this chapter is, it nevertheless contains the essence of quantitative tools required to proceed to subsequent chapters. Furthermore, this very chapter could be the core of a mathematics course that would be a prerequisite for the subjects that follow in subsequent chapters. In such a course, certain concepts could be modified and extended. For example, one might consider emphasizing the role of quaternions, as opposed to the Euler angles, to enjoy the simplicity of the algebraic, as opposed to trigonometric, operations for general rotations in three dimensions.

Chapter 2 begins with a brief introduction to continuum mechanics. Therein, the concepts of stress, strain, stress-strain relations, and strain energy are introduced. Again, this aspect of that chapter could be the core of an elasticity course that would be a prerequisite for the subjects that follow in subsequent chapters. The chapter proceeds—within the continuum-mechanics context—with the equations of motion and the wave equation, in a manner familiar to students of mathematical physics. As indicated by their titles, the subsequent eight chapters address both the essence and various specific aspects of quantitative seismology. A potential reader interested in more details might refer to the “Front Matter” within the online resource, www.cambridge.org/krebes. Therein, the titles of numerous subsections provide a detailed insight into the material covered in the book. This resource contains additional student exercises with solutions as well as the slides of all figures in the book and a solution manual for end-of-chapter exercises, which are password-protected and available to lecturers who order the book for their courses. Also, the online resource contains corrections and clarifications to the first printing of “Seismic Wave Theory,” which are accessible to all and are updated by the author.

The study of this outstanding book allows the students to become conversant in issues of quantitative seismology. It provides a well-established structure of a rich subject to be followed by lecturers. The book can also serve as a bridge for mathematicians, physicists, and mechanical engineers who wish to engage in seismology, since—methodologically—seismology is a branch of mathematics, physics, and continuum mechanics, even though its applications make it a part of geosciences. Within this book, the aforementioned scientists find familiar concepts applied to the study of terrestrial problems—concepts without which seismology cannot exist.

This book is a result of many years of fruitful lecturing and educating seismologists for both academia and industry. Hence, its style is exceptionally clear and guides the readers in a most comfortable manner, with concepts whose presentation flows seamlessly without creating unnecessary doubt or confusion.

Thanks to the balanced choices of subjects and their careful presentation, “Seismic Wave Theory” should become a classic textbook for quantitative seismology, a subject that—sensu stricto—cannot be but quantitative.

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