is given to fill this gap. This is the first instance in which the author's choice to give almost no references at all is unfortunate. The interested student will have to fill the gap or ask the instructor for a reference. Chapters 4 and 5 offer a standard treatment of series. Chapters 6 and 7 are more abstract and introduce metric spaces and present results on continuous (real or complex) functions on metric spaces. A high point is Bernstein's proof of the Weierstrass approximation theorem, including a nice probabilistic interpretation of a key inequality. Chapter 8 is titled "Calculus" and in twenty pages covers differentiation and Riemann integration for functions of one real variable and includes the fundamental theorem of calculus and Taylor's theorem. The chapter on special functions contains an elementary proof of the fundamental theorem of algebra and a proof of Euler's product formula, $\sin x = x\prod_1^\infty(1-\frac{x^2}{\pi^2 n^2})$, with some of the details left to exercises.

Chapters 10 through 14 are the core of the book and treat the Lebesgue integral and Fourier analysis. As one of the interesting aspects of Fourier analysis the uncertainty principle is discussed. The proof is only sketched and the author does not make clear why it is only a sketch. For example, he does not make clear that the operator $\frac{\partial}{\partial x}$ is not defined on all of $L^2(\mathbf{R})$. Moreover, no reference is given for a complete proof. It would have been easy to refer the student to [3]. The fast Fourier transform is also mentioned, again with no references. Eventually this sort of informal discussion accumulates to give the impression of a set of lecture notes that have not yet become a text. The book finishes with the Cauchy–Peano existence theorem and the Picard–Lindelöf uniqueness theorem for solutions of ordinary differential equations.

With a few exceptions (fundamental theorem of algebra, Banach–Tarski paradox, Weyl's equidistribution theorem, etc.), the material of this book is usually included in a senior course in real analysis. The exercises are well designed and the exposition (apart from annoying misprints) is clear. However, there is no coverage of functions of several variables and the treatment of every topic is brief. There are essentially no references to other sources. This reviewer would continue to recommend [1] or [5] as the text for the intended course.

REFERENCES

[1] T. M. Apostol, *Mathematical Analysis*, 2nd ed., Addison-Wesley, Reading, MA, 1974.

[2] R. G. Bartle, *The Elements of Real Analysis*, 2nd ed., John Wiley, New York, 1976.

[3] G. Folland and A. Sitarm, *The uncertainty principle: A mathematical survey*, J. Fourier Anal. Appl., 4 (1997), pp. 207–238.

[4] T. Korner, *A Companion to Analysis*, AMS, Providence, RI, 2004.

[5] W. Rudin, *Principles of Mathematical Analysis*, 3rd ed., McGraw-Hill, New York, 1976.

[6] W. Thron, *Functions of Complex Variables*, John Wiley, New York, 1953.

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**Fundamentals of Seismic Wave Propagation.** *By Chris Chapman*. Cambridge University Press, Cambridge, UK, 2004. $75.00. 632 pp., hardcover. ISBN 0-521-81538-X.

One of the themes of this book is the use of asymptotic ray methods to perform seismic modeling. With increasingly fast computers direct numerical solutions can be performed for heterogeneous media, but the solutions are often still too slow for intensive seismic modeling and inversion, particularly in three dimensions. The methods presented in this book are orders of magnitude faster than finite difference or finite element methods and also provide more physical insight into how seismic waves propagate. Although the book is very clear and insightful, the presentation is advanced and may not be easy for readers in the more applied sciences. The developments presented in the book, however, provide a unique perspective based on the author's experience and prior work, which make it well worth the effort of reading.

Although the book assumes a basic knowledge of seismic waves, the author provides the preliminaries needed to be useful to nonseismologists reading this book. The author then presents an initial overview of the basic properties of seismic waves in different media, including plots of rays and travel-times. However, this could have been postponed until after the presentations on transforms and continuum mechanics for a better flow of the material. In any case, it does immerse the reader immediately into wave concepts. The author provides a geometric view of rays and travel-times that are familiar to many seismologists, but I would have liked more intuitive descriptions of the different travel-time graphs displayed. For example, plots of ray parameter p, which is the slope of the travel-time curve, and the intercept time can be confusing. But, for smooth, vertically varying media displaying the inverse of p with the intercept time results in a stretched version of the original velocity model, and the inverse problem involves converting this to velocity with depth. However, the author here is not emphasizing the inverse problem but rather the forward modeling of rays and travel-times for specific models. Nonetheless, more physical intuition of these travel-time graphs would have been useful. The author then gives a good overview of different ray-tracing algorithms and their merits.

Temporal and spatial transforms used for wave propagation are presented next. This includes an excellent description of the Legendre transform and also a good section on the Radon transform which is useful for both seismic modeling as described here, as well as inverse problems. This is followed by a terse but excellent overview of continuum methods related to the propagation of elastic waves. The author derives the representation theorems, reciprocity of the Green functions, and the equations of motion. He presents the simpler acoustic case first and then goes directly to the general anisotropic elastic case, with isotropic elasticity as a special case. Homogeneous point and line source Green functions are derived as well as moment tensor descriptions of compact seismic sources.

Asymptotic ray theory is then presented for both the acoustic and anisotropic elastic cases. Although the author notes that this is valid for wavelengths small compared with the heterogeneities and propagation distance, a more detailed discussion of regions of validity for the ray method would have been useful. The ray equations are then derived from the ray series solution and the Hamiltonian approach in phase space is described along with Fermat's principle. The energy transport equations are presented, followed by a description of the paraxial ray equations which are important for the calculation of geometric spreading, ray interpolation, and ray perturbation theory. But the discussion of paraxial rays is fairly terse and could have benefited from several illustrative examples. Although going from acoustic to anisotropic ray theory is straightforward, for many (including myself) this is a large jump. However, the derivations are clear and warrant repeated readings. The special case of isotropic ray theory is derived separately. Although the first impression is that anisotropic ray theory is the most general form, as the author notes, care must be taken in directions where the S wave branches touch. Since anisotropy in the Earth is usually less then 10%, another serious difficulty is that ray theory may breakdown generally for weakly anisotropic media except at very high frequencies. This is addressed in detail in the last section of the book on generalizations of ray theory using quasi-isotropic shear wave coupling.

The interaction of rays with smooth interfaces is presented next. The author first describes kinematic rays at boundaries, and then dynamic paraxial rays. This is followed by derivations of reflection and transmission coefficients which are asymptotically valid for rays considered as local plane waves. Both the acoustic and the anisotropic cases are described where the author correctly notes that the coefficients must be given together with appropriate eigenvectors to be useful. Examples are then presented of different coefficients with angle or ray parameter. The author notes that these coefficients can be used to invert for material properties in different situations including the identification of oil reservoir rocks using AVO (amplitude versus offset) analysis. Linearizations of coefficients using perturbation analysis are presented which are useful for the inverse problem as well as for forward modeling. Ray theoretical Green functions in media with interfaces are then given.

The differential equations for waves in stratified media are derived starting with the acoustic case and then the general anisotropic case. The author notes that the complete solutions often don't give insights into the individual signals propagating in layered media. In addition, complete solutions can be numerically unstable when waves become evanescent in some layers. To address these issues, he first presents Kennett's ray expansion approach. Alternative numerically stable approaches for the complete response are described, including expansions in terms of second order minors. For inhomogeneous smooth layers, the WKBJ asymptotic and iterative solutions are described and applied to second order and higher discontinuities. For turning rays within a smoothly varying layer, he describes the Langer approximation. Chapman finally presents an interesting alternative method for stratified media using a Langer block-diagonal decomposition and second order minors.

The author next describes how inverse transforms of the wave solutions can be computed. The first method given is the Cagniard–de Hoop–Pekeris method where the space-time solution can be obtained by a deformation of the ray parameter contour. When the WKBJ approximation can be applied, the inverse transforms can also be approximately evaluated, resulting in the WKBJ seismogram method. To make this approach numerically stable, band limiting the response on the order of the time sampling is used. The author then describes various spectral approaches where the slowness integral is evaluated first, followed by the frequency integral. He next presents solutions to different canonical problems including direct and turning rays, head waves and total reflections, interface and tunneling waves, and caustics and shadow zones.

I found the last section of the book to be the most interesting, where the author gives a number of extensions to the ray method. The first extension is Maslov's method for laterally heterogeneous media, where the response is written as a slowness-style integral response. Similar to the WKBJ seismogram method, band limited Maslov seismograms can be obtained in the space and time domain. Nonetheless, artifacts can occur from pseudocaustics in the transformed domain, and although these don't coincide with regular caustics, they can be nearby for complex media. Other extensions to the ray method that I would have liked to see described here are Gaussian beam summation and coherent state methods that blend solutions in order to avoid some of these difficulties. In any case, a good discussion of the Maslov seismogram method is given. The next extension described is quasi-isotropic methods for weakly anisotropic media. Degenerate ray perturbation theory is first described and then quasi-isotropic shear wave coupling for weak anisotropy. Born scattering theory is then presented which extends ray theory to incorporate signals from perturbations in the background medium, as well as from inaccuracies in the ray solution. Both the acoustic and elastic cases are described. Finally, Kirchhoff surface integral theory for diffractions from nonplanar interfaces is presented.

As can be seen from the topics covered in the book, the author provides a wealth of information about seismic wave propagation from a unique vantage point. The book could be used for a one-semester class in seismic wave propagation but at the advanced level. There are also a number of useful problems at the end of each chapter. Several topics, however, are not presented in the book, including normal modes, viscoelasticity and seismic attenuation, and finite difference and element methods. Also, ray method extensions like coherent states or Gaussian beams are not covered. Even without these, there is enough material in the book that the reader will probably need to pick and choose. Nonetheless, this is an essential book for any applied scientist or mathematician interested in asymptotic methods for the propagation of seismic waves.

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**Working Analysis.** *By Jeffery Cooper.* Elsevier Science & Technology, Amsterdam, 2004. $99.95. xvi+663 pp., hardcover. ISBN 0-12-187604-7.