mology, starting from basic elasticity and wave propagation (ray theory and wave theory) and moves on to well-known techniques in reflection seismology and elementary introductions to source theory and earthquake prediction. There is a good selection of problems after each chapter, with some identified as computer projects. These computer assignments are excellent problems for laboratory work typically associated with a seismology course in the US.

Although Shearer's book can be used for self-study, it is in essence a textbook to be used with an instructor. As an introductory course textbook for upper-level undergraduate students (and perhaps some graduate students with no previous exposure to seismology), it may be the best textbook available now. For more advanced students, aiming to become seismologists, Udías's book provides an excellent, broad overview of seismology. I would be happy to go through it in reading courses with my own graduate students. It would be a good introduction for students who are to become well-balanced researchers.

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Radiative Transfer in the Atmosphere and Ocean

Gary E. Thomas
and Knut Stamnes
Cambridge U. P., New York, 1999.
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The transfer of solar and thermal radiation within a coupled atmosphere–surface system is of fundamental importance in Earth and planetary sciences. Applications include energetics and climate modeling as well as remote sensing and photochemistry. Despite its critical role, radiative transfer is often found to be a relatively frustrating field for students. This may be due, in part, to the lack of good introductory texts and the many disciplinary backgrounds of students in Earth science programs (physics, chemistry, engineering, meteorology, and the like).

The new offering by Gary Thomas and Knut Stamnes, *Radiative Transfer in the Atmosphere and Ocean*, is the culmination of the authors' teaching efforts over many years. It is a welcome addition to the small number of existing alternatives concerned with radiative transfer fundamentals and tools. The text is intended for advanced undergraduates and beginning graduate students in atmospheric and oceanic sciences, but it also provides a useful reference for the practitioner. Our review draws on our involvement in the development of a graduate course for which the book served as the main text.

A strength of the book is its early effort to emphasize the fundamental physics underlying radiative interactions and to provide useful insight. It uses the classical Lorentz theory for describing molecular scattering and line shapes, and it describes nicely quantum mechanical considerations pertinent to molecular absorption. These discussions are not intended to be for detailed descriptions (as, for instance, is *Atmospheric Radiation: Theoretical Basis* by Richard M. Goody and Yuk L. Yung, Oxford, 1989). The same can be said of the brief introduction to Mie (spherical particle) scattering; other texts can be consulted for the full mathematical derivation. Polarization is not discussed.

The intuitive fashion in which the various incarnations of the radiative transfer equation and its solutions are developed is another strength. Chapter 7 is a thorough treatment of the two-stream approximation and examines a large number of special cases. Chapter 8, on "accurate" numerical techniques, emphasizes the discrete ordinate method and follows nicely from the two-stream discussion. One may argue, however, that the 40-page presentation is at the expense of other methods that are arguably more intuitive and also widely used. These include, for instance adding/doubling, successive orders of scattering, and Monte Carlo methods. Although both chapters are rich in numerical detail, the unsophisticated reader would benefit from additional instructive examples and figures. For instance, a summary of radiance and flux dependencies on optical thickness, particle absorption, and solar geometry would have been valuable.

We appreciated the clear review of climate issues and the summary of radiative transfer concepts for climate applications presented in the last two chapters. Two details that drew our attention in these chapters were the summary plots of atmospheric absorption spectra in chapter 11, usually presented much earlier in books of this type, and the exclusive use of the term "greenhouse effect" in chapter 12 for a mathematical quantity.

A major concern is the book's seemingly awkward organization. In particular, some theoretical details are delayed until later chapters on applications. For example, a student introduced to the fundamentals of absorption in chapter 4 might logically proceed to single-line transmission and band models (including k-distributions), rather than postponing the discussion until chapter 10. Other organizational difficulties include the apparent lack of a unifying theme in chapters 5 and 6 (somewhat abstractly titled "Principles of Radiative Transfer" and "Formulation of Radiative Transfer Problems," respectively). Topics in chapter 5 range from the definition of bidirectional reflectance to the radiative transfer equation solution in the absence of scattering; topics in chapter 6 range from scaling transformations for anisotropic scattering to the principle of reciprocity.

Another concern is notation. The authors follow the uncommon conventions of H. C. van de Hulst (*Multiple Light Scattering*, Academic, 1980), but they also make unorthodox choices for subscripts and superscripts (for example, the direct solar beam is indicated with a superscript s, although the corresponding angles use the common subscript 0 notation). Especially disconcerting is the common notation shared by numerous reflection and transmission functions, whose meanings (and units) depend on the arguments.

We had mixed feelings about the problem sets. They are more extensive than in previous texts but are often too challenging without adding much insight. More introductory problems would have been helpful.

All in all, this is a valuable resource for those interested in terrestrial radiative transfer. It contains good discussions and physical explanations within the main text, useful summaries, notes, comments, and up-to-date references. Prospective instructors should be aware that the extensive amount of material in the book makes it appropriate for a two-semester course.

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The Diamond Makers

Robert M. Hazen
Cambridge U. P., New York, 1999.
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People have treasured diamonds for thousands of years because of their unrivaled hardness and their brilliance as jewels. When early chemists (1797) found that diamond is a crystalline form of pure elemental carbon they, along with physicists, engineers, and various kinds of experimenters, tried to make diamond from cheaper, baser forms of carbon or carbon compounds.

Robert Hazen's *The Diamond Makers*, is a compelling, nontechnical narrative covering centuries of history related to diamond, centered mostly around brilliant, often eccentric and controversial pioneers of research at high pressures. Success at diamond synthesis did not come until the science of thermodynamics in chemistry and physics had developed to the degree that it could indicate the parameters of possible reaction paths. Further, new geometries and construction materials had to be developed to make possible high-pressure apparatus capable of simultaneously generating and holding pressures and temperatures higher than had ever been achieved before. The chemical-physical reaction condition also proved to be quite subtle. Although dozens of scientific articles and reports on the subject were published during the 19th and 20th centuries, *The Diamond Makers* is the first major publication to cover the whole period from the human point of view, while maintaining scientific integrity.

Hazen is well qualified in many respects to write this book. He is an active scientist at the Geophysical Laboratory of the Carnegie Institution of Washington. For many years, as a side activity, he has written books for young people and the general public portraying the excitement and the human side of scientific research. For example, his 1988 book *The Breakthrough*, (Summit), is a thrilling account of the race to find, develop, and understand higher-temperature superconductors. It is written in a style that has the drama and suspense of a murder mystery, yet is true to the science.

In *The Diamond Makers*, Hazen gives a thorough and exciting account of the history of diamonds and the efforts to synthesize them. Many famous scientists and engineers took their turns at trying to make diamond from baser forms of carbon. Final reproducible success was not attained until the 1950s, after scientists had developed adequate thermodynamic understanding, the high-pressure–high-temperature apparatus, and the reaction path needed. Much human drama was involved.

In preparation for writing the book, Hazen did a thorough job of studying the relevant scientific literature, and he interviewed personally those still living who had been involved in the diamond-making story. From the interviewees, besides their own stories, he drew much recollected information about their predecessors. As one of the surviving diamond-makers, I am able to vouch for the thorough and open-minded interviews Hazen conducted.

In 1951, I was the first of the General Electric Research Laboratory scientists to be assigned to the problem of diamond synthesis. My target was the theory of reaction paths within thermodynamically stable conditions. After the first reproducible successful synthesis by team member H. Tracy Hall in late 1954, I continued for 30 years to help to establish experimentally the pressure–temperature phase diagram of carbon. I also helped to develop apparatus and techniques to extend the range of laboratory high-pressure research to about 70 gigapascals (~700 000 atm) and high-temperature parameters to the 2.5 K-to-6000 K range.

The book begins by treating the situation as it was in prehistoric times, when people had learned by experience much about materials found in nature and how they could be shaped and used effectively. One of the ancient artisan's "secrets" was that different kinds of stone could be arranged in a hierarchy of hardness, and the harder ones could be used to shape or dress the softer ones. Of all the kinds of stones, diamond was the hardest and could be used to work the hardest of other stones. Such diamond tool-stones were rare, highly prized, and carefully guarded by ancient artisans.

The major part of the book is devoted to portraying the people and teams of people who worked toward the actual synthesis of diamond, and the interactions and rivalries that existed among them. In addition to the successful high-pressure–temperature, catalyst-solvent process, which is used worldwide today to produce nearly all synthesized industrial diamond, later chapters in the book cover two other developments: an explosive shock-compression process that converts a dispersion of graphite particles in suitable thermal quenching media into fine-grained diamond powder, and a low-pressure chemical vapor deposition (CVD) process, carried out under thermodynamically unstable conditions that can produce films or thin plates of crystalline diamond carbon on selected substrates. The last part of the book deals with efforts of scientists