head in the Geysers field in California. The different resource quality of the two fields (wet and dry steam, respectively) requires totally different wellhead equipment and this figure is consequently misleading.

In summary, although the book would have benefited from more critical editing this would not have been sufficient to overcome its main disadvantage, that of the delay between the compilation and publication. Consequently, it cannot be recommended.

J.D. GARNISH (Harwell)

Free Oscillations of the Earth. E.R. Lapwood and T. Usami. Cambridge University Press, Cambridge, 1981, xii + 243 pp., £25.00, ISBN 0-521-23536-7.

The gravest modes of seismic vibration are of such long periods that attenuation is very low and the whole Earth rings for several days after being excited by a large enough earthquake. This book describes how Lamb set up the basic equations for the vibrations of a uniform sphere at the end of the last century, and Benioff first recorded free oscillations after the Kamchatka earthquake of 1952. This stimulated the instrumental and theoretical developments leading to the calculation of the lowest periods of the free oscillations for fairly realistic Earth models. However, it was not until suitable instrumentation coincided with the availability of high-speed digital computers for spectral analysis and calculation of eigenfrequencies and eigenfunctions that the systematic description of free oscillations could begin. Dr. Lapwood and Professor Usami have both contributed significantly to this development. They have now written an eminently readable book describing how the remote interior of the Earth affects observations of free oscillations at the surface by a comparatively simple theory overlain by complications caused by gravitation and rotation of the Earth and by attenuation, discontinuities, and other departures from homogeneity. They begin by giving the historical background, and then develop the theory step by step adding complications one at a time in an easily followed sequence. They progress from the eigenfrequencies and eigenfunctions of a uniform elastic sphere, through a uniform shell, a two-layered sphere, a self-gravitating layered sphere, to a realistic Earth model, including splitting of eigenfrequencies by the rotation of the Earth, and the generation of free oscillations by earthquakes, which can supply unique information about the long period behaviour of earthquake sources. As the book presents them, these results can be said to be straightforward, in that they describe the behaviour of an axially-symmetric Earth, that can be used as a tool to examine details of Earth structure and details of the long period earthquake sources.

The final chapters contain the most exciting possibilities for research in the future: the attempt to map inhomogeneities in the deep interior of the Earth, which will probably be the most important contribution that free oscillations will make to the study of the Earth. These are: analysing the solotone effect (the deviation of the observed eigenfrequencies from their asymptotic calculated values, due to the distribution of discontinuities within the Earth); and the splitting of eigenfrequencies by lateral inhomogeneities and anisotropy. The authors describe all these formidable problems with elegance and simplicity. I did find the captions to some of the figures rather inadequate, especially those borrowed from research papers. I did expect rather more emphasis on the value of frequency splitting for examining inhomogeneities, particularly as splitting may well provide information about inhomogeneities before the overall inverse solution of free oscillations is perfected. I believe the authors have caught free oscillations at a plateau of development; a very appropriate time to write an enduring textbook. However, the subject is not at rest. More progress can be confidently expected from the underlying uncertainty of sentences beginning "We may reasonably expect..." and "From experience... we can confidently expect...", and indeed several important papers have already appeared since the book was written.

This is a fine introductory textbook to a vastly involved topic of great importance to Earth Science, that has long been needed. Unusually clear, with every step referenced, it deserves a place on every Geophysicist's shelf, and well worth 10 p a page of anybody's money.

STUART CRAMPIN (Edinburgh)

An Introduction to the Mathematical Theory of Geophysical Fluid Dynamics. S. Friedlander, Elsevier, Amsterdam, 1980, 282 pp., U.S.$29.50, Dfl.65.00, ISBN 0-444-86032-0

Let me begin with my conclusions. The author and publishers should get together to produce a reprint of this book that is free from the numerous, mainly typographical, errors; and this should be offered for sale at a reasonable price. We would then have a most useful addition to the literature, filling a niche in a sensible and unpretentious way.

In making this recommendation, one has to make it clear just what this niche is, in terms of both what the book covers and what background it assumes of the reader. With the burgeoning of the subject in the last twenty years, the phrase "Geophysical Fluid Dynamics" no longer conveys the same to all people. There is, for example, only a passing mention of convection in this book. It is essentially an introduction to the theory of the dynamics of rotating fluids, about equally divided between homogeneous fluids and flows in which stratification also affects the dynamics. There is brief consideration of stratified, non-rotating flows but done in a way that much underplays the importance of such flows. Further, the author's statement that her book considers "a certain class of fluid motions in the Earth" is not quite accurate. Rather, it considers a range of basic fluid dynamical phenomena that have their more complex counterparts in nature. There are occasional brief accounts of the application of some of the topics to natural phenomena (usually oceanographic, although the most extended is astrophysical), as also there are of laboratory experiments; but there is no attempt at a systematic treatment of these matters. None of this is a criticism of anything other than, perhaps, the book's title.

Friedlander assumes previous familiarity with basic fluid dynamics. The equations are asserted without derivation or much explanation, and, for example, the non-dimensional parameters are introduced in an extremely brief chapter the purpose of which would not be apparent to someone new to fluid dynamics. The ideal reader would be a student of applied mathematics who had already taken courses in "non-geophysical" fluid dynamics and who wished to extend his/her knowledge to include rotating fluids. The book would also be useful to the student of meteorology or oceanography wishing to understand relevant fluid dynamics through a fairly formal treatment of the fundamentals (but requiring a less advanced text than Greenspan's "The Theory of Rotating Fluids"). To have this understanding in a proper context, however, the student would need not only to have previous knowledge of the equations, but also to learn from other sources about topics such as instability and turbulent flow. To some extent I think that it is a pity that Friedlander's book is not more self-contained. I am strongly of the opinion that fluid dynamics has a unity that makes it undesirable for 'geophysical' topics to be studied in isolation from 'non-geophysical' (or vice-versa), but the progression need not always be from the latter to the former.

Within its terms of reference, however, Friedlander's book gives a sensibly-organised and cogent account of the basic theory of flow in a rotating frame. The two unifying themes are the determination of various types of wave solution and the use of boundary layer methods. These illustrate well the complexity and subtlety of Coriolis force dominated flows and the mathematical methods developed for handling them. I am less happy with the half-hearted treatment of instability. There is just one chapter on baroclinic instability, treated at a more elementary level (entirely inviscid) than the rest of the book. Whilst this is undoubtedly an important topic, it fails to convey adequately the importance of stability considerations throughout the subject. It is odd, for instance, that Ekman layers and Stewartson layers are considered in some detail without any mention that they both exhibit instabilities.

As indicated above, the book is marred by a plethora of misprints. Many of these are merely irritating, but some change the meaning or appear