quite illustrative.

In Chapter 10, the author continues development of structural response under random loadings for continuous parameter structures as formulated by partial differential equations, basing his approach on modal decomposition. He rests his development on the response of a beam to random distributed loadings, and then treats the case of point loads random in time, which is referred to as Crandall's problem. Finally, Chapter 10 closes with a discussion of random vibrations due to boundary layer turbulence using the piston theory formulation.

Professor Elishakoff completes the text with Chapter 11, which is titled "Monte Carlo Method," and is concerned with the problem of random number generation and computer simulation for the numerical study of the response of structures to random excitations. In this chapter it is shown that the analytical relations thus far studied are not enough for engineers, they must also be able to analyze numerically for design purposes. The author illustrates how to generate purely random numbers, random variables with a given distribution, random functions by eigenfunction representation and finally he presents a statistical study of buckling of an imperfect bar on a non-linear foundation by simulation. In this chapter, one is taken from analytical development to the practicality of numerical simulation and numerical experiment. Clearly, the second half of the text provides the basis for an excellent graduate course on random vibrations and buckling. There is a comprehensive selection of references at the end of each chapter with suggestions for further reading.

We must now ask, where does this book fit in the ever-increasing collection of books on probabilistic and stochastic methods? It does not contain an advanced development requiring ideas of stochastic differential equations, Ito calculus, etc., nor is it a text on elementary probability or elementary random function theory. It is, as was the author's goal, a development of tools and the applications of these tools to structural problems in which uncertainty is present. As such, in this reviewer's opinion, Professor Elishakoff has presented us with an outstanding instrument for teaching.

Frank Kozin
Polytechnic University

## *Flow Induced Vibration of Circular Cylindrical Structures*

Shoei-Sheng Chen, Hemisphere Publishing Corp., NY, 1987, 464 pp., $110.00.

Flow past a cylinder, or an arrangement of cylinders, represents a generic type of flow-structure interaction that has widespread practical ramifications. Offshore structures and heat exchanger tube bundles are typical of the variety of configurations of current importance. It is therefore no surprise that an entire book can be dedicated to flow-induced vibration of cylindrical structures. Such an overview is important not only for the practicing engineer but also for the researcher who, more than ever, is deluged with an ever-growing body of design information and research results.

This book methodically takes the reader through concepts of increasing complexity, starting with the simplest case of a single cylinder in quiescent fluid and extending to the very complicated case of fluid-elastic instabilities of arrays of cylinders in cross-flow. The types of flows addressed are not limited to incompressible, single-phase flows. The author creates an awareness of the importance of compressibility and its relevance to acoustically induced vibration of a cylinder. Effects of two-phase flow are also covered. Finally, in problems of this type, effects of nonlinearity and three-dimensionality are always of concern, and the author provides information on these aspects.

After addressing the (relatively) simple case of a single cylinder in quiescent fluid, the author points out many key physical features of multiple cylinders in quiescent fluids. Although certain of these aspects are not directly applicable to systems with flowing fluid, there are practical situations where cylinder vibration in non-flowing fluids does occur. Perhaps more important, however, is the effort to make the reader aware of important concepts such as multiple vibrational modes and multiple natural frequencies of groups of cylinders. This can be very nicely illustrated in absence of mean flow.

As a prelude to a discussion of circular cylinders immersed in flow in the direction of their axes (i.e., an axial flow), the reader is provided with a chapter on pipes conveying fluid. Of course, this topic is of obvious importance, and the effects of hydrostatic fluid pressure, gravity, and damping forces, as well as several other effects, are accounted for. For the case of circular cylinders in axial flow, the most common practical configuration involves a number of cylinders arranged so that their axes are parallel; an account is given of the behavior of such multiple cylinder arrays. This class of problems is also viewed with respect to the concept of near-field flow noise and its possiblity for exciting cylinder vibration.

In the event that a cylinder is oriented such that its axis is orthogonal to the flow direction, then there occurs massive flow separation on the downstream side of the cylinder, making it necessary to consider the intricacies of the unsteadiness of the separated flow region. In its complete form, this class of problems challenges our knowledge of transition and turbulence in shear flows, an area that is still not describable in simple terms, even when speaking of the fluid mechanics divorced from the body that generates the separated flow. The author provides a view of a number of aspects of a single cylinder in cross flow, including the variation of flow loading as a function of Reynolds number; this topic, in itself, provides the researcher and designer with a rich spectrum of challenges. The coupling between the unsteady fluid motion and the oscillation of the cylinder has long been of interest, and the author discusses the modelling of such phenomena.

The flow-induced vibration of an array of circular cylinders in cross-flow probably represents the most complex class of problems in the area of flow-structure interaction. Various types of correlations, and a review of attempts to explain the mechanisms occurring in such arrays, are presented in this section of the book. Very often, one encounters occurrence of acoustic resonance within such a tube array in engineering practice. As a consequence, the designer is confronted with the parallel to Wall Street's triple witching hour: triple coincidence of the natural frequencies of the unsteady flow, the cylindrical structures, and the resonant acoustic modes of the system. Again, creation of awareness that all of these aspects exist is indeed important.

The book concludes with interesting chapters addressing the somewhat simpler case of two cylinders in cross-flow, as well as a chapter entitled fluid-elastic instability that focusses on some of the important points that must be considered in describing vibrating cylinders and systems of them.

This book will be useful for both researchers and designers, especially those well versed in the mathematics describing this class of problems. Particularly welcome is a book from one who has himself contributed substantially to the development of a discipline; such is the case for this book.

Donald Rockwell
Lehigh University

## *Turbulence in Fluids*

Marcel Lesieur, Martinus Nijhoff Publishers, Boston, 1987, 286 pp., $68.50.

Some people think that turbulence is a tiny specialty within fluid mechanics, which is itself a small part of mechanics, an antique section of physics, which is just one of the sciences. There is a certain truth to this, which makes it nearly incomprehensible that the field could be so inhomogeneous, that a book on turbulence could have such a distinctive flavor, be so unmistakably identified with a particular world-view. This is a nice book, a useful book, and I like it. There is no escaping the fact, however, that it is certainly a physicist's book, maybe even a European physicist's book. That is even a good thing, but still inescapable.

This flavor results largely from the author's concentration on spectral methods and homogeneous flows, both isotropic and two-dimensional/quasi-geostrophic, and from the coverage of three- and two-dimensional EDQNM (Eddy Damped Quasi-Normal Markovian), DIA (Direct Interaction Approximation), the Test Field Model and other stochastic models, and such subjects as predictability theory and internal intermittency, and the Craya decomposition. Many people in the engineering community, and in the United States in particular (with less respect learned at Mother's knee for education and intellectual activity) were wearied long ago by these mathematically complex structures that seem to speak only to physical situations so pure as to have little relevance to real problems. Partly this is a failure on their part to recognize how difficult the turbulence problem really is; the strongly inhomogeneous and anisotropic flows that occur in technologically important situations are (for the most part) much too complicated to attack in any fundamental way at our present level of understanding. In these homogeneous flows we are attempting to understand energy transfer from large to small scales, something that happens in all turbulent flows. When we get that right, maybe we can move on. You can understand, however, the impatience with this point of view of a Program Monitor at an agency of the Department of Defense.

This book is fairly committed to the statistical approach. Lesieur returns from time to time to the question of coherent structures, although the opportunities for this are limited, since coherent structures are not much in evidence in homogeneous flows. Lesieur believes, as I do, that turbulent flows have varying amounts of structure, depending on boundary and initial conditions, but that even when considerable spatial organization is present there is a stochastic element, causing jitter in all the parameters of the structures, so that a statistical approach may still be the most sensible. Lesieur rightly makes no apology for the use of Reynolds averaging, and does not address the specious nonsense that such averaging obscures information.

In addition to the above, there is a nice introduction with a good selection of real and computer generated pictures of turbulence of all scales. There is a brief discussion of chaos. There is a section on direct numerical simulation and large eddy simulation of turbulence, as well as sections on absolute equilibrium ensembles and the diffusion of passive scalars. The book closes with a very brief discussion of stably stratified turbulence and the two-dimensional mixing layer.

All in all, this would be a useful text for a first course in turbulence for physicists, or as a second course for engineering students who have already had a more phenomenological introduction to the subject. It is a useful reference for the specialist who may not keep at his fingertips some of the details of the analytical theories and stochastic models.