

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.

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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 possibility 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

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J. R. Bowen, J. C. Leyer, and R. I. Soloukhin, editors

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