Book Review

Advanced Theory of Vibration (Nonlinear Vibration and One Dimensional Structures), by J. S. Rao. Published by John Wiley & Sons, Inc., New York, 1992. $25.50, 431 pp.

As the author has pointed out in his preface, vibration analysis has drawn liberally from such diverse fields as mechanical and electrical engineering, strength of materials, structural mechanics, nonlinear analysis, and variational calculus, with the result that much of what is now considered as part of advanced theory of vibration is scattered over numerous publications relating to different disciplines. The present book is intended to present a comprehensive, yet concise, consolidation of the relevant literature for the benefit of advanced students aspiring to specialize in the vibrations field.

Professor Rao has succeeded admirably in his intent. He has written a text that is essentially self-contained and well arranged from the pedagogical viewpoint. Although most of the text is mathematical, the author explains the needs for the various analyses in terms of the physical systems to which they apply, and he draws general practical conclusions from the theoretical results where possible. The level of the mathematical presentation is such that anyone comfortable with advanced engineering mathematics should have no difficulty in working with this text on his own.

The subtitle essentially indicates the book's limitation to two major subject areas: nonlinear vibration of systems with a single degree of freedom and linear and nonlinear vibration of one dimensional systems. After a brief introduction presented in Chapter 1, Chapter 2 addresses free vibrations of simple systems and discusses some well-known related analytical and numerical techniques. Corresponding stability considerations and criteria are presented in Chapter 3, together with graphical, analytical, and numerical methods. Forced oscillations of simple systems, including transient and limit responses, are addressed in Chapter 4, again together with various relevant evaluation methods.

Chapter 5, entitled "Variational Principles," begins with a review of the basics of the calculus of variations and then presents the principle of virtual work, Hamilton's principle, complimentary virtual work, and Reissner's principles. It also presents and illustrates applications of the numerical techniques of Lagrange, Ritz, and Galerkin, which are based on variational principles. These principles are applied to longitudinally vibrating bars in Chapter 6, to torsional vibrations of rods in Chapter 7, and to lateral vibrations of beams in the last chapter, Chapter 8.

Chapter 6 includes derivations of Raleigh's and Bishop's theories, as well as treatment of nonuniform, viscoelastic, and viscoelastically coated bars. Chapter 7 derives the theories of St. Venant, Love, and Timoshenko–Gere in a unified manner and also addresses torsional vibrations of pretwisted tapered rods. It further derives the more accurate theories of Reissner, Lo–Goulard, and Barr, and deals with stress analysis by several approaches.

The final chapter begins with Bernoulli–Euler theory of beams, then adds rotatory inertia and shear effects and points out the classical theories' limitations from the view point of linear elasticity before deriving Volterra's theory. It also addresses such special cases as beams with

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axial loads, beams on elastic foundations, viscoelastic beams on viscoelastic foundations, and layered beams. Further, it deals with pretwisted beams, in which motions in two different planes are coupled, and it addresses beams with asymmetric cross sections, in which bending and torsional motions are coupled. Finally, it discusses vibrations of rotating beams, where Coriolis forces lead to nonlinearity, and deals with stress analysis of vibrating beams by use of Reissner's variational functional.

Five useful appendices contribute to the "stand alone" usefulness of this text: Appendix 1 summarizes tensor notation, Appendix 2 presents Gauss' theorem, Appendix 3 gives an overview of the principles of linear elasticity, Appendix 4 consists of a summary of linear viscoelasticity, and Appendix 5 is a table of Laplace transforms. The text's comprehensive list of symbols should permit one to get into it relatively readily at virtually any point; its extensive selected bibliography should prove useful for the more detailed pursuit of specific topics.

This unique text deserves thorough study by every serious student of advanced mechanical vibrations, as well as an honored place on the reference book shelf of every practitioner in the field.

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