Advanced Mechanical Vibrations: Physics, Mathematics and Applications
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1 PURPOSE

According to the author, "this book is aimed at intermediate-advanced students of engineering, physics and mathematics." This description seems accurate from the review of the contents and presentation. However, it is heavily weighted to an applied mathematics treatment of the topic. It is much more a text in the mathematics of vibration than the solution of vibration problems.

2 SUMMARY

Not written as an introductory text in vibrations, this book begins assuming that a complex multi-degree-of-freedom system is to be described and establishes the concepts and mathematics to handle such a case. This text may be best described as an applied mathematics presentation on vibrations with the development of governing equations and solutions from basic principles. It provides a comprehensive treatment of the concepts behind both commonly used formulations and specialized cases. The text is broad in covering the whole subject of vibration in 320 pages. Consequently, the author is not able to provide practical examples or provide detailed examples of the use of the mathematics presented in understanding the vibration of real mechanical systems.

Overall, the material is presented in a logical and progressive fashion. It would lead a student for the first concepts to more advanced treatments in the mathematics of mechanical vibrations. It would be a useful supplement for a graduate engineering course on vibrations or a text for an applied mathematics course in the same area.

3 DISCUSSION

3.1 Chapter 1: A Few Preliminary Fundamentals

This is a very brief overview of the concepts of vibration. In ten pages, the author covers the concepts of masses, springs, and dampers in a basic sense. The application of force and different measurements of response in terms of displacement, velocity, and acceleration are also presented. It is assumed that the reader is already familiar with the basic concepts of vibration, and this chapter is a reminder of these principles.

3.2 Chapter 2: Formulating the Equations of Motion

This is a generalized discussion of the mechanics and the equations of motion for dynamic systems. Using the principles of conservation of work and energy, a rigorous presentation of the mathematics to describe system motion in a rigorous general form is presented.

This presentation is mathematically well defined. There is emphasis on the types of mathematical functions and formal names for the types of formulations. For instance, Hamilton's principle is verified with a mathematical proof. It is of interest for advanced students to see the mathematics behind the classic forms of vibration analysis and for those wishing to consider cases that violate some of the simplifying assumptions used in more basic approaches. Special cases such as motion in a non-inertial reference frame, non-small oscillations, and a uniformly rotating reference frame are considered. In a sense, this is more like an applied mathematics treatment than a traditional engineering treatment of vibration formulations.

3.3 Chapter 3: Finite DOFs Systems: Free Vibrations

For this chapter, the author goes back to the small amplitude assumption to begin the consideration of finite degree of freedom systems. With this assumption, the author establishes the principles of the orthogonality of eigenvectors and demonstrates the treatment of some simple problems with no loss terms.

Next comes the treatment of special cases: light damping as a perturbation of the undamped case, unrestrained systems, variations on the type and amount of damping.

3.4 Chapter 4: Finite-DOFs Systems: Response to External Excitation

Moving to the response to external excitation, the author begins with an impulse response and develops the equations for generalized systems of excitation. Treatments include the step function, a rectangular pulse, base displacement, and harmonic and periodic excitation. This is a more rigorous treatment than many vibration texts and would be useful to those interested in cases that fall outside the traditional simplified vibration problems.

After establishing a rigorous mathematical foundation, the author moves to multiple degree of freedom systems. After demonstrating the basic formulation, the author moves to alternative solutions and cases. He provides multiple state-space formulations. At the end of this chapter, frequency response functions are defined and demonstrated for a simple example and some discussion about the receptance matrix.

3.5 Chapter 5: Vibrations of Continuous Systems

The chapter begins with the fundamental concept of the flexible string and defines the equations of motion for different end points. It then moves along the classical path from flexible bars to a membrane, bending beams, and then to plates. As in the previous chapters, detailed mathematical formulations are presented with notes on the implications of the formulations and their solutions.

3.6 Chapter 6: Random Vibrations

The author begins by defining random excitation with a thorough treatment of the characteristics of signals. The analysis techniques to define relationships between signals and the amount of correlation are also discussed.

The next segment of this chapter is devoted to spectral analysis beginning with the definition of random processes. The author presents a comprehensive discussion of the topic with a discussion of the properties of Fourier transforms and several special cases. In addition, operations such as singular value decomposition are described.

3.7 Appendix A: On Matrices and Linear Spaces

This appendix is devoted to matrices and liner operations with matrices. The basic principles of such operations are presented with some simple examples of the processes. This is a comprehensive treatment of the basic concepts but is limited in the examples of usage.

The next section of this appendix focuses on eigenvalues and eigenvectors. There are examples of different forms of eigenvector matrices and their properties.

3.8 Appendix B: Fourier Series, Fourier and Laplace Transforms

Both Fourier and Laplace transforms are presented in this appendix. The basic equations and their variations are presented with useful discussion of the Dirac delta function.

4 RECOMMENDATIONS

With the understanding that this is an applied mathematics text in mechanical vibrations, I would recommend this book to those who would want to understand the math behind the principles and equations used in vibrations. It is logically presented and very comprehensive at a high level in describing the mathematics of vibrations. It also could be helpful as a supplemental text in a high-level engineering graduate course on mechanical vibrations.

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