Book review

Mechanical and Structural Dynamics by Demeter G. Fectis, Wiley, New York, 1995, 804 pp., ISBN: 0-471-10600-3.

The mechanical and structural vibrations aspects of designing and analyzing dynamic systems has been well integrated into this textbook. This work is an update to the author's *Dynamics and Vibration of Structures*, published in 1973. This earlier version was well received by practicing engineers as I'm sure the current textbook will be. This updated test provides the engineering community with the latest knowledge on the vibration and dynamic response of structural and mechanical systems. The demand for lighter more efficient systems will become increasingly important as we enter the 21st century, the need to predict their dynamic behavior will become more important than every before.

Chapter 1 outlines free and forced vibrations for both discrete and continuous systems. It discusses linear and non-linear systems, as well as some of the current research being done with chaotic vibrations. This chapter provides a good overview of the subject matter that follows.

Chapter 2 discusses the free vibration of a single degree of freedom linear spring–mass and torsional disk–shaft systems. The influence of viscous, Coulomb and hysteresis damping is reviewed. This chapter continues with a discussion of systems with two or more degrees of freedom, both with and without damping including some comparative examples. This is followed by the development of transverse, longitudinal and torsional vibration analysis of uniform beams. The chapter concludes with a discussion of the wave equation. The material presented in this chapter is developed in a very clear and concise manor with easy to follow examples.

Chapter 3 provides an in-depth coverage of forced vibrations. The effects of harmonic forces both damped and undamped are described and illustrated. This is followed by describing the dynamic response due to a general force of arbitrary time variation. Two techniques for analyzing periodic, but not harmonic, forcing functions of this type, namely the Fourier series and a numerical extrapolation technique, are described and illustrated in the text. The next section discusses the methodology for predicting the dynamic response of idealized beams and frames in both the elastic and the elastic-plastic region of the material. This section summarizes work on blast resistant design developed in the late 1950's and early 1960's and has application today to earthquakes resistant systems.

Chapter 4 deals with the dynamic response of continuous system. It includes the analysis of continuous beams with a constant EI and when EI is allowed to vary from span to span. It discusses the vibration characteristics of a variety of structural elements including cables, stretched membranes, simply supported rectangular plates, beam columns, and beams on elastic supports. He introduces the concept of a dynamic hinge which is an extension of the work described by Benjamin in *Statically Indeterminate Structure* (1959) and the unique properties of inflection points in continuous systems. This chapter provides the necessary analytical tools to look at a variety of real world problems.

Chapter 5 deals with more complex structures using the classical approximate methods. They include the Rayleigh method which equates the total maximum potential energy to the total kinetic energy using an assumed mode shape. Stodala's method which is based on the concept of inertia forces and the use of influence coefficient. This method is well suited for determining the fundamental frequency and mode shape of beams and shafts. Myklested method may be thought of as an extension of the Holzer method extensively used for torsional vibration. However, for the bending frequencies of beams and shafts it's somewhat more complicated and employs the use of transfer matrices. This material is well presented and is easy to follow.

Chapter 6 provides an overview of the finite element method of analysis based on the stiffness method. It discusses stiffness and mass matrices of both beams and plates. This is followed by the assemblage of the global stiffness and mass matrices including the introduction of external loads and boundary condition. It discusses the Jacobi method for solving the eigenvalue problem, i.e., to determine the free vibration of the structure. Finally it discusses the two techniques available for solving problems relating to forced vibration namely by direct integration and model superposition. Both techniques are illustrated with some simple example.

Chapter 7 is well written and discusses the techniques of modal superposition to solve a variety of real

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world problems using simple models. This method is extremely useful as it lends itself to determining not only the natural frequencies and mode shapes of the structure but also its dynamics stresses and displacements. This techniques draws on the knowledge from several of the previous chapters.

Chapter 8 presents some useful techniques for analyzing beam elements which contains geometric and/or material non-linearities, by converting these non-linearities to an equivalent pseudolinear system. This technique allows one to proceed using the conventional linear methods described in the previous chapters. These techniques offer a good check for more complicated non-linear finite element solutions.

Chapter 9 uses the methods of transformed calculus which involves Fourier and Laplace transformations to determine the dynamic response of structural and mechanical systems to both periodic and non-periodic excitation. The Fourier and Laplace transform method is developed and illustrated with several examples.

Chapter 10 discusses variational and stochastic approaches to solving vibration problems. The primary emphasis of this chapter is devoted to the subject of random vibrations. The basic theory is developed but unlike the rest of the text this important subject is left very theoretical and without much in the way of examples on how to apply the techniques to real world problems. Most of the mechanical and structural systems being specified today and in the future will be required to survive and live in a random vibration environment. The author spends a considerable amount of time describing an acoustic method for predicting concrete material response which was informative but of limited value. The chapter would have been better served had this space been devoted to illustrating the method of analyzing a system which is subjected to random vibration.

Chapter 11 is devoted to developing scale models which can be used to determine the dynamic response of complicated systems. It has been the writer's experience that modeling such things as damping is very difficult to scale. However, this technique does provide a means to obtain a physical understanding of a complicated mechanical, structural system.

There are several useful appendices along with the answers to selected problems at the end of the textbook. The answers provide the reader with an opportunity to ensure that he has a good grasp of the subject matter.

This is a high quality textbook which will be useful to both college students and practicing engineers. It emphasizes the use of developing simple models to gain a physical understanding of the subject matter which is also useful to validating the more complicated analytical models. I found this textbook written in a clear and concise manner and recommend it to anyone interested in the subject of mechanical and structural vibrations.

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