Preface

The helicopter is a complicated dynamic system. A key aspect of the helicopter is the main rotor which provides lift, propulsive thrust, and control capacity. Modeling of helicopter rotor dynamics is complicated by highly flexible blades and aerodynamics. Comprehensive books on helicopter dynamics have been written. However, they typically derive and discuss the rigid blade equations and provide a cursory treatment to the elastic blade equations, aerodynamic modeling, and solution method for blade response and stability. Thus, a large pedagogical gap exists between the helicopter dynamic books and the theory manuals of the comprehensive rotor codes. This book tries to fill this gap.

We explain the basics of helicopter dynamics which are needed for solving helicopter problems. We take a detailed approach toward the problem of elastic rotating blade, a problem which involves a partial differential equation in space and time and requires a numerical solution. Finite element method plays an important role here, first in space and later in time.

Chapter 1 provides a background on the vibration of discrete and continuous system. It introduces the momentum theory and blade element theory and presents the rigid and elastic flapping blade. The elastic blade equation is derived at the end of Chap. 1. This is a partial differential equation with periodic coefficients and forcing terms. Chapter 2 discusses the finite element method and its use to discretize the rotor blade equation in the spatial domain. Methods to calculate the rotating beam natural frequencies and mode shapes are presented. The aerodynamic forces are also formulated on this chapter. Chapter 3 discusses the finite element method in time, a technique which is ideal for calculating the steady response for periodic systems. This method is illustrated for some periodic differential equations and then used for elastic rotor blade problem. A p-version of the finite element in time is introduced in this chapter. Chapter 4 presents the stability analysis of the elastic blade equation. The constant coefficient approach is illustrated for the rotor in hover. Then, Floquet theory is developed for periodic systems in forward flight.

Finally, the last chapter gives some numerical results for a typical helicopter rotor blade. Frequency analysis, blade response calculation, and stability analysis are presented.

This book will help graduate students and researchers to understand the typical derivations and solution methods used in aeroelastic analysis of helicopter blades.

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Ranjan Ganguli
Vijay Panchore

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