Nonlinear Vibration with Control for Flexible and Adaptive Structures, Second Edition
David Wagg and Simon Neild
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It really was a pleasure reviewing the latest edition of Wagg and Neild's graduate-level textbook. The text reads like a guided logical inquiry into the field of nonlinear control, drawing upon the student's understanding of linear vibration theory with good and relatable examples of the demising boundaries between the two. Each chapter begins with an abstract which serves as both a summary for the concepts to be discussed and an explanation of how the concepts fit within the study and application of nonlinear vibration control. Each chapter ends with chapter notes, which relate the text to references for further study. Problems are given to exercise the student's understanding of chapters 2, 3 and 4, with complete answers worked out in chapter 9.

Chapter 1 introduces the concept of smart structures and the naturally occurring causes of nonlinearity which require control. Causes are grouped into material hysteresis, geometric nonlinearity such as pendulums under large displacements, and externally applied forces and constraints such as those that occur for airfoils, ferrofluidics, mechanical freeplay and control system delays.

Starting with sinusoidal analysis of linear systems, Chapter 1 shows how similar mathematical modeling of nonlinear systems results in harmonics within the response. The response becomes increasingly complicated as the displacement grows. Therefore, the convenient method of superposition no longer holds for the study of nonlinear systems, and other methods must be used.

With a lack of exact solutions, Chapter 2 introduces methods of numerical simulations, dynamical system theory and state space mapping for the study of nonlinear systems. The chapter reviews these methods as applied to linear harmonic systems and progresses to linear approximation, bifurcation systems and harshly nonlinear systems such as friction oscillators (e.g. squealing brakes) and impact oscillators (e.g. light standard chain dampers). The chapter ends by introducing higher order nonlinear phenomena such as solitons, chaos, localization and mode veering and the methods being used to study them.

Chapter 3 develops the methods for control of nonlinear vibrations. Passive methods include tuned mass dampers, inerters and nonlinear isolators (e.g. negative stiffness spring mechanisms). Semi-active methods center on the skyhook, high/low viscosity damper. Active methods expand control theory to nonlinear systems and adaptive control for systems with variable parameters.

Chapter 4 introduces approximate methods for analysis, beginning with finding the “backbone curve” effect of nonlinearity, which warps resonance peaks into the shape of a dorsal fin. Perturbation theory applications are followed by normal form transformations of weak nonlinear systems (used to solve the near linear responses while maintaining information about the nonlinearities).

Chapter 5 builds upon normal form transformations to define nonlinear modal deflections and resonance peaks and to develop nonlinear modal analysis in general.

Chapter 6 expands linear beam theory to the nonlinear realm of large deflections and axial loading. An example of vibration control of a piezoelectric bimorph beam is given.

Chapter 7 extends the linearized cable equations to include nonlinear dynamic tension and cross-coupling between quasi-static and modal terms. Case studies are given to demonstrate nonlinear effects.

Chapter 8 expands linear plate theory to include nonlinear effects of in-plane loading and then develops the equations for shells, demonstrating how higher-order terms introduce nonlinearity and subharmonics as the shell becomes less shallow. The chapter ends with a short introduction to the study of adaptive structures such as bi- and multi-stable composites.

Chapter 9 gives thoroughly-worked-out solutions to problems within the book.

Wagg and Neild's *Nonlinear Vibration with Control* is an easy study for the student and a valuable reference for the engineer.

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