Le, Khanh Chau

Energy methods in dynamics. (English) Zbl 1243.74001


The aim of this textbook is to help students acquire both a good grasp of the principles from which the governing equations can be derived, and the adequate mathematical methods for their analysis. The distinctive feature of the book is a systematic intensive use of Hamilton’s variational principle and its generalizations for deriving the governing equations of conservative and dissipative mechanical systems, and also in performing the direct variational-asymptotic analysis of the energy and dissipation for the solution of these equations.

The first chapter deals with small vibrations of the simplest mechanical systems, namely of oscillators having only one degree of freedom. In the second chapter, small vibrations of mechanical systems with many degrees of freedom are considered. The well-known effective methods for conservative and dissipative systems are discussed in detail. The next chapter deals with small vibrations of mechanical systems with an infinite number of degrees of freedom. The continuum models of strings, beams, membranes and plates are discussed. The vibrations of general continuous oscillators are found in form of a linear superposition of standing waves. The author also considers eigenvalue problems in infinite-dimensional spaces for such solutions.

The linear waves propagating in continuous media are studied in the fourth chapter. The solutions for weakly inhomogeneous media are obtained on the basis of the variational-asymptotic method. The fifth chapter examines finite-amplitude vibrations of autonomous systems with one degree of freedom. The phase portraits, Lindstedt-Poincaré methods for conservative systems and Bogolyubov-Mitropolski̇j method for systems with weak dissipation are discussed in detail. The sixth chapter presents the variational-asymptotic method for non-autonomous systems with one degree of freedom whose Lagrange function depends explicitly on time.

The seventh chapter deals with finite-amplitude vibrations of coupled oscillators having two or more degrees of freedom. Numerical solutions are obtained by the Poincaré maps, and the variational-asymptotic analysis is applied to systems with weak coupling. The final chapter analyzes the exact solutions of several nonlinear equations of wave propagation obtained by the inverse scattering transform.

The material of this textbook can be recommended as a one-year course in higher dynamics for graduate students of mechanical and civil engineering.

Reviewer: Irina Alexandrovna Bolgrabskaya (Donetsk)

MSC:

74-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mechanics of deformable solids
70-01 Introductory exposition (textbooks, tutorial papers, etc.) pertaining to mechanics of particles and systems
74H45 Vibrations in dynamical problems in solid mechanics
74J05 Linear waves in solid mechanics
70H25 Hamilton’s principle
70Kxx Nonlinear dynamics in mechanics

Keywords:
variational-asymptotic analysis; Hamilton’s principle; linear wave; Lindstedt-Poincaré method; Bogolyubov-Mitropolski̇j method

Software:
Mathematica