

J. Kevorkian
J.D. Cole

Applied
Mathematical
Sciences
114

Multiple Scale and Singular Perturbation Methods



Springer

Contents

Preface	v
1. Introduction	1
1.1. Order Symbols, Uniformity	1
1.2. Asymptotic Expansion of a Given Function	5
1.3. Regular Expansions for Ordinary and Partial Differential Equations	19
References	35
2. Limit Process Expansions for Ordinary Differential Equations	36
2.1. The Linear Oscillator	36
2.2. Linear Singular Perturbation Problems with Variable Coefficients	53
2.3. Model Nonlinear Example for Singular Perturbations	82
2.4. Singular Boundary Problems	95
2.5. Higher-Order Example: Beam String	110
References	117
3. Limit Process Expansions for Partial Differential Equations	118
3.1. Limit Process Expansions for Second-Order Partial Differential Equations	118
3.2. Boundary-Layer Theory in Viscous, Incompressible Flow	164
3.3. Singular Boundary Problems	182
References	264
4. The Method of Multiple Scales for Ordinary Differential Equations	267
4.1. Method of Strained Coordinates for Periodic Solutions	268
4.2. Two Scale Expansions for the Weakly Nonlinear Autonomous Oscillator	280

4.3. Multiple-Scale Expansions for General Weakly Nonlinear Oscillators	307
4.4. Two-Scale Expansions for Strictly Nonlinear Oscillators	359
4.5. Multiple-Scale Expansions for Systems of First-Order Equations in Standard Form	386
References	408
5. Near-Identity Averaging Transformations: Transient and Sustained Resonance	410
5.1. General Systems in Standard Form: Nonresonant Solutions	411
5.2. Hamiltonian System in Standard Form; Nonresonant Solutions	440
5.3. Order Reduction and Global Adiabatic Invariants for Solutions in Resonance	482
5.4. Prescribed Frequency Variations, Transient Resonance	502
5.5. Frequencies that Depend on the Actions, Transient or Sustained Resonance	513
References	520
6. Multiple-Scale Expansions for Partial Differential Equations	522
6.1. Nearly Periodic Waves	522
6.2. Weakly Nonlinear Conservation Laws	551
6.3. Multiple-Scale Homogenization	614
References	619
Index	621

This book is a revised and updated version, including a substantial portion of new material, of the authors' widely acclaimed earlier text, *Perturbation Methods in Applied Mathematics* (AMS 34). A new chapter dealing with regular expansions has been added, the discussion of layer-type singular perturbations has been revised, and the coverage of multiple scale and averaging methods has been significantly expanded to reflect recent advances and viewpoints. The result is a comprehensive account of the various perturbation techniques currently used in the sciences and engineering that is suitable both as a graduate text and as a reference work on the subject.

ISBN 0-387-94202-5

