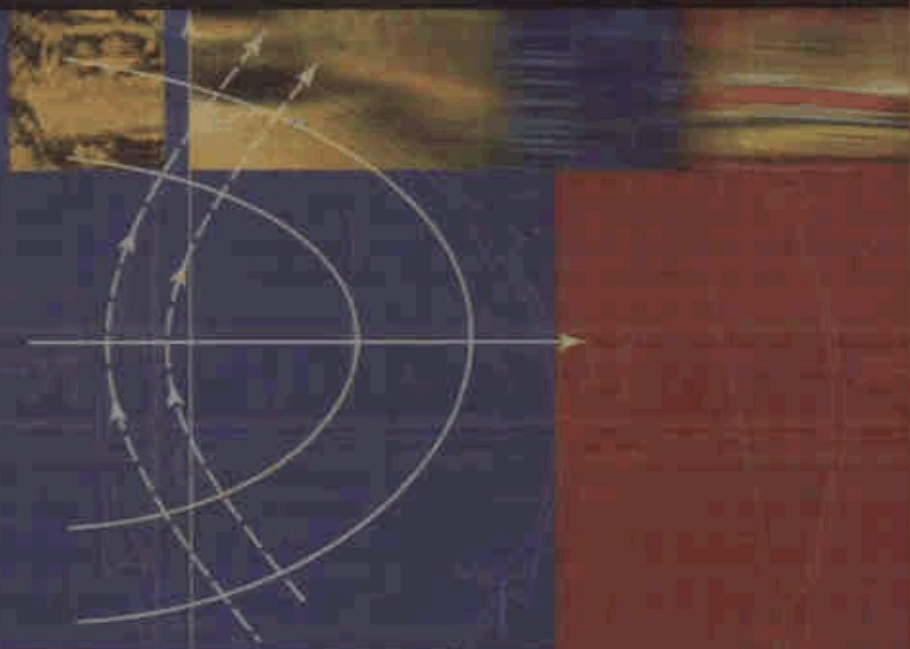


INTERNATIONAL EDITION

3rd Edition

Complex Variables with Applications



A. David Wunsch

Contents

Introduction **xi**

1

Complex Numbers **1**

- 1.1 Introduction 1
- 1.2 More Properties of Complex Numbers 9
- 1.3 Complex Numbers and the Argand Plane 14
- 1.4 Integer and Fractional Powers of Complex Numbers 28
- 1.5 Points, Sets, Loci, and Regions in the Complex Plane 39

2

The Complex Function and Its Derivative **49**

- 2.1 Introduction 49
- 2.2 Limits and Continuity 55
- 2.3 The Complex Derivative 63
- 2.4 The Derivative and Analyticity 70
- 2.5 Harmonic Functions 80
- 2.6 Some Physical Applications of Harmonic Functions 87

3

The Basic Transcendental Functions

99

- 3.1 The Exponential Function 99
 - 3.2 Trigonometric Functions 107
 - 3.3 Hyperbolic Functions 113
 - 3.4 The Logarithmic Function 115
 - 3.5 Analyticity of the Logarithmic Function 120
 - 3.6 Complex Exponentials 128
 - 3.7 Inverse Trigonometric and Hyperbolic Functions 133
 - 3.8 More on Branch Cuts and Branch Points 138
- Appendix: Phasors

4

Integration in the Complex Plane

153

- 4.1 Introduction to Line Integration 153
 - 4.2 Complex Line Integration 160
 - 4.3 Contour Integration and Green's Theorem 172
 - 4.4 Path Independence, Indefinite Integrals, Fundamental Theorem of Calculus in the Complex Plane 182
 - 4.5 The Cauchy Integral Formula and Its Extension 192
 - 4.6 Some Applications of the Cauchy Integral Formula 203
 - 4.7 Introduction to Dirichlet Problems—The Poisson Integral Formula for the Circle and Half Plane 214
- Appendix: Green's Theorem in the Plane

5

Infinite Series Involving a Complex Variable

229

- 5.1 Introduction and Review of Real Series 229
- 5.2 Complex Sequences and Convergence of Complex Series 232
- 5.3 Uniform Convergence of Series 242
- 5.4 Power Series and Taylor Series 249
- 5.5 Techniques for Obtaining Taylor Series Expansions 264
- 5.6 Laurent Series 279

- 5.7 Properties of Analytic Functions Related to Taylor Series: Isolation of Zeros, Analytic Continuation, Zeta Function, Reflection 296
- 5.8 The z Transformation 307
- Appendix: Fractals and the Mandelbrot Set

6

Residues and Their Use in Integration 335

- 6.1 Introduction and Definition of the Residue 335
- 6.2 Isolated Singularities 342
- 6.3 Finding the Residue 352
- 6.4 Evaluation of Real Integrals with Residue Calculus, I 361
- 6.5 Evaluation of Integrals, II 365
- 6.6 Evaluation of Integrals, III 374
- 6.7 Integrals Involving Indented Contours 388
- 6.8 Contour Integrations Involving Branch Points and Branch Cuts 395
- 6.9 Residue Calculus Applied to Fourier Transforms 404
- 6.10 The Hilbert Transform 416
- 6.11 Uniform Convergence of Integrals and the Gamma Function 431
- 6.12 Principle of the Argument 442

7

Laplace Transforms and Stability of Systems 453

- 7.1 Laplace Transforms and Their Inversion 453
- 7.2 Stability—An Introduction 480
- 7.3 The Nyquist Stability Criterion 490
- 7.4 Generalized Functions, Laplace Transforms, and Stability 498

8

Conformal Mapping and Some of Its Applications 517

- 8.1 Introduction 517
- 8.2 The Conformal Property 519
- 8.3 One-to-One Mappings and Mappings of Regions 528
- 8.4 The Bilinear Transformation 537
- 8.5 Conformal Mapping and Boundary Value Problems 555
- 8.6 More on Boundary Value Problems—Streamlines as Boundaries 576

x Contents

- 8.7** Boundary Value Problems with Sources 586
8.8 The Schwarz–Christoffel Transformation 605
Appendix: The Stream Function and Capacitance

9

Advanced Topics in Infinite Series and Products	625
9.1 The Use of Residues to Sum Certain Numerical Series	626
9.2 Partial Fraction Expansions of Functions with an Infinite Number of Poles	633
9.3 Introduction to Infinite Products	641
9.4 Expanding Functions in Infinite Products	650
Solutions to Odd-Numbered Exercises	659
Index	669