COMPLEX ANALYSIS

A First Course with Applications

THIRD EDITION

Dennis G. Zill | Patrick D. Shanahan

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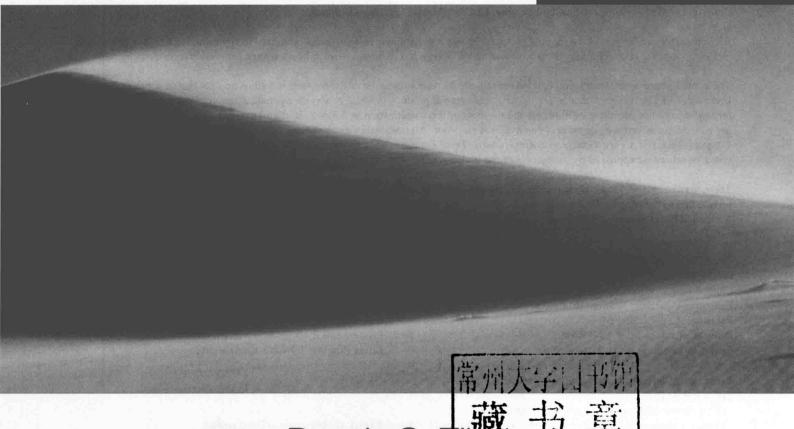JONES & BARTLETT
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The Jones & Bartlett Learning International Series in Mathematics

For Dana, Kasey, and Cody

Preface

☐ **Philosophy** The first edition of this text grew out the material in Chapters 17–20 of *Advanced Engineering Mathematics, Third Edition* (Jones and Bartlett Publishers, 2006), by Dennis G. Zill and the late Michael R. Cullen. This third edition represents an expansion and revision of that original material and is intended for use either in a one-semester or a one-quarter course. Its aim is to introduce the basic principles and applications of complex analysis to undergraduates who have no prior knowledge of this subject. The writing is straightforward and reflects the no-nonsense style of *Advanced Engineering Mathematics*.

The motivation to adapt the material from *Advanced Engineering Mathematics* into a stand-alone text came from our dissatisfaction with the succession of textbooks that we have used over the years in our departmental undergraduate course offering in complex analysis. It has been our experience that books claiming to be accessible to undergraduates were often written at a level that was too high for our audience. The "audience" for our junior-level course consists of some majors in mathematics, some majors in physics, but mostly majors from electrical engineering and computer science. At our institution, a typical student majoring in science or engineering is not required to take theory-oriented mathematics courses such as methods of proof, linear algebra, abstract algebra, advanced calculus, or introductory real analysis. The only prerequisite for our undergraduate course in complex analysis is the completion of the third semester of the calculus sequence. For the most part, then, calculus is all that we assume by way of preparation for a student to use this text, although some working knowledge of differential equations would be helpful in the sections devoted to applications. We have kept the theory in this text to what we hope is a manageable level, concentrating only on what we feel is necessary in a first course. Many concepts are presented in an informal and conceptual style rather than in the conventional definition/theorem/proof format. We think it would be fair to characterize this text as a continuation of the study of calculus, but this time as the study of the calculus of functions of a complex variable. But do not misinterpret the preceding words; we have not abandoned theory in favor of "cookbook recipes." Proofs of major results are presented and much of the standard terminology is used throughout. Indeed, there are many problems in the exercise sets where a student is asked to prove something. We readily admit that any student—not just majors in mathematics—can gain some mathematical maturity and insight by attempting a proof. However, we also know that most students have no idea how to start a proof. Thus, in some of our "proof" problems the reader is either guided through the starting steps or is provided a strong hint on how to proceed.

☐ **Changes in This Edition** The original underlying philosophy and the overall number of sections and chapters are the same as in the second edition. We have purposely kept the number of chapters in this text to seven. This was done in order to provide an appropriate quantity of material so that most of it can reasonably be covered in a one-term course.

Our primary goal for this third edition was to enhance the strengths of the original text. As such, in this revision:

- Some text in Chapter 2 has been rewritten in order to support a more direct transition from elementary principles to series and residues. As with previous editions, we have tried to keep the exposition crisp and straightforward.

- Section 2.6 (Limits and Continuity) in the second edition has now become Section 3.1 in this edition. This move collects all of the introductory concepts of the calculus of complex functions into Chapter 3 as well as balances out the number of sections in each chapter.
- Some new problems have been added to the exercises and many problems from the previous edition have been improved. A significant number of computer lab assignments have also been added.
- The *Mathematica*® syntax from the second edition has been updated to coincide with version 8 of the software.
- Errors and typos in the second edition have been corrected.

☐ **Features of This Text** We have retained many of the features of the previous edition. Each chapter begins with its own opening page that includes a table of contents and a brief introduction describing the material to be covered in the chapter. Moreover, each section in a chapter starts with introductory comments on the specifics covered in that section. Almost every section ends with a feature called *Remarks*, in which we talk to the students about areas where real and complex calculus differ or discuss additional interesting topics (such as the Riemann sphere and Riemann surfaces), which are related to, but not formally covered in, the section. Several of the longer sections, although unified by subject matter, have been partitioned into subsections; this was done to facilitate covering the material over several class periods. The corresponding exercise sets were divided in the same manner in order to make easier the assignment of homework. Comments, clarifications, and some words of caution are liberally scattered throughout the text by means of marginal annotations.

We have used a double-decimal numeration system for the numbering of the figures, theorems, and definitions. For example, the interpretation of "Figure 1.2.3" is

$$\text{Chapter} \rightharpoondown \quad \leftharpoondown \text{Section}$$
$$1.2.3 \leftarrow \text{Third figure in the section}$$

We feel that this type of numeration will make it easier to find figures, theorems, and definitions when they are referred to in later sections or chapters.

We have provided a lot of examples and have tried very hard to supply all pertinent details in their solution. Because applications of complex analysis are often compiled into a single chapter placed at the end of the text, instructors are sometimes hard-pressed to cover any applications in the course. Complex analysis is a powerful tool in applied mathematics. So to facilitate covering this beautiful aspect of the subject, we have chosen to end each chapter with a separate section on applications.

The exercise sets are constructed in a pyramidal fashion, and each set has at least two parts. The first part of an exercise set is a generous supply of routine drill-type problems; the second part consists of conceptual word and geometrical problems. In many exercise sets there is a third part devoted to the use of technology. Since the default operational mode of all computer algebra systems is complex analysis, we have placed an emphasis on that type of software. Although we have discussed the use of *Mathematica* in the text proper, the problems are generic in nature.

Each chapter ends with a Chapter Review Quiz. We thought that something more conceptual would be a bit more interesting than the rehashing of the same old problems given in the traditional Chapter Review Exercises.

Answers to selected odd-numbered problems are given in the back of the text. Since the conceptual problems could also be used as topics for classroom discussion, we decided not to include their answers.

☐ **Additional Resources** A student study guide has been prepared by Patrick D. Shanahan to accompany *Complex Analysis: A First Course with Applications.*

The study guide contains a complete solution of every fourth problem in the exercises (with the exception of Focus on Concepts and Computer Lab Assignment problems), hints for every fourth Focus on Concepts problem, summaries of the key ideas for each section, and important review material from calculus and differential equations.

Complete solutions are also available for qualified instructors. For student and instructor resources please contact your Jones & Bartlett Learning account representative at 1-800-832-0034 or visit go.jblearning.com/complex3e.

☐ **Acknowledgments** We would like to express our appreciation to our colleagues at Loyola Marymount University who have taught from the text, as well as those instructors who have taken the time to contact us, for their words of encouragement, criticisms, corrections, and thoughtful suggestions. We also wish to acknowledge the valuable input from past LMU students who used this book in preliminary and published versions. Finally, we extend a deeply felt thank you to the reviewers of the first and second editions:

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Lastly, many kudos goes to our Production Editor, Tiffany Sliter, for yet another job well done.

☐ **Final Request** Compiling a mathematics text, even one of this modest size, entails juggling thousands of words and symbols. Experience has taught us that errors—typos or just plain mistakes—seem to be an inescapable by-product of the textbook-writing endeavor. We apologize in advance for any errors that you may find and urge you to bring them to our attention. You can email them to our editor at info@jblearning.com.

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