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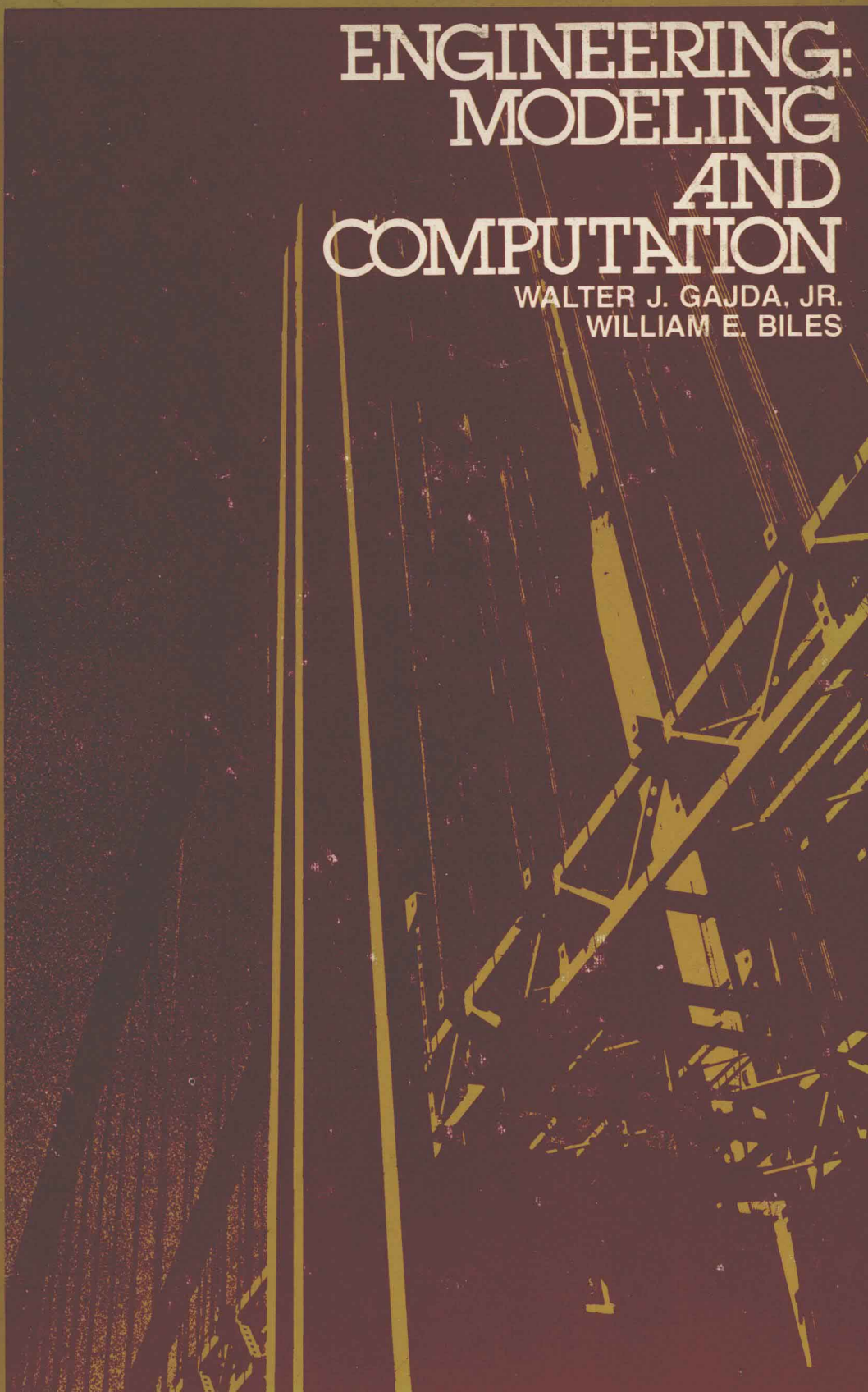

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TO OUR PARENTS

AND THE PARENTS OF OUR WIVES

PREFACE

Almost every new engineering student takes a course that introduces him or her to the study of engineering. Many textbooks have been written for this purpose and many different approaches to teaching introductory courses have been tried. Although these approaches can be categorized only in the most general terms, they can be said to be divided into two types.

The first type of introductory engineering course emphasizes a qualitative treatment of such topics as the history of engineering, professional standards and ethics, descriptions of the various fields within engineering, the types of jobs performed by engineers, and the approaches engineers take in designing and analyzing engineering entities. This first type of course describes *what* the engineer does.

The second type of introductory engineering course treats the quantitative tools engineers use in solving problems. Such a course requires the student to develop analytical techniques and exercise them in the solution of problems. This type of course describes *how* the engineer solves problems.

This textbook is designed for the second type of course. It stresses the development of models, and the mastering of computational tools and techniques necessary to manipulate these models to solve engineering problems.

This book has evolved from a decade of experience at the University of Notre Dame in teaching a course entitled Introduction to Engineering Concepts. For several years, this course examined the slide rule and the digital computer as computational devices needed in the study and practice of engineering, with a majority of the course devoted to the FORTRAN programming language. Problems from various engineering fields were examined, procedures for solving problems were described, and the students were required to develop the FORTRAN programs necessary for solving these problems. This approach afforded the freshmen engineering students exposure to typical problems from all engineering fields, and it imparted specific computational skills.

The engineering faculty observed, however, that students tended to regard the computer as an end in itself rather than the computational tool that it should be at this early stage of their education. There was also a strong opinion that FORTRAN programming did not justify an entire three-credit course. In response to these faculty reactions, we made an effort four years ago to broaden and systematize the engineering concepts to which the student was introduced, while retaining the

essentials of FORTRAN programming. An initial attempt to use two textbooks simultaneously—one to introduce the desired engineering concepts and another to present FORTRAN programming—was unsatisfactory to faculty and students alike. It was apparent to us that we needed an introductory engineering textbook that would integrate fundamental engineering concepts with FORTRAN programming. We developed this textbook in response to that need.

This book is unusual among introductory engineering texts in that it presents to the reader such modern engineering topics as modeling, optimization, feedback and input/output analysis, probability and economic analysis within a framework of utilizing scientific and mathematical skills to solve engineering problems. We have tried to tread a path between oversimplification and excessive complexity, to demonstrate that engineering is an intellectually demanding endeavor, and to encourage and stimulate students to see engineering as an exciting and challenging career. The reactions of our students over the last three years have confirmed our belief that this textbook accomplishes those objectives.

This is not a book for marking time. It makes demands on both students and teachers. It is intended to motivate the student to master the science and mathematics that form the cornerstone of modern engineering education and that so often appear as hurdles to new students.

We have recognized engineering students' need to master computational tools and techniques early in their programs of study. We have observed the fascination that the seemingly boundless power of the digital computer holds for new students. Hence we have introduced FORTRAN programming early in the text (Chapter 3), and we have woven many examples and problems into succeeding chapters. We hope that engineering faculty and students will concur that computer programming can best be taught to engineering students by engineers in an engineering setting.

The book contains more than enough material for a one-semester course. The organization affords the opportunity to select course material in keeping with the specific future needs of a particular engineering program. For example, Chapter 8 treats probabilistic models in engineering. If a given engineering program requires a later course in engineering probability—as is the case at Notre Dame—the instructor might exclude Chapter 8 from an introductory engineering course. If no such course is required later, however, the instructor could devote as many as six or eight class periods to probabilistic models. The same is true of Chapters 9 and 10, which examine economic and feedback models, respectively. Even Chapter 1, which contains an extensive section on the electronic calculator, offers a choice in that the instructor can choose to allow the student to absorb that material in a self-study assignment. Chapters 2 through 7 represent fundamental engineering concepts that should be covered, at least in part, in any introductory engineering course.

The sequence of coverage makes flexibility feasible. If an instructor wants to expose students to such topics as modeling, units and dimensions, and optimization methods before giving any attention to computer programming, Chapter 3 could be covered after Chapter 5. Certain material in Chapter 5 requires a knowledge of differential calculus. If students are taking an introductory engineering course concurrently with a first calculus course, it may be necessary either to delay certain topics in Chapter 5 or to delete them entirely. Chapter 7 contains developments in

both differential and integral calculus, but the instructor can treat these developments without relying on students having a rigorous understanding of calculus.

ACKNOWLEDGMENTS

We take pleasure in acknowledging the contributions of all those who helped in the development of this book. In particular, we thank the hundreds of students who have waded through poorly edited manuscripts. Some complained and most were patient, but all of them made valuable comments. We thank the many Notre Dame faculty members, past and present, who have taught the Introduction to Engineering Concepts course over the last decade. They have contributed engineering problems, comments, editing, corrections, and sometimes simply support and encouragement. Their influence is indelibly stamped on these pages and on the minds of the Notre Dame students who have taken this course. Professors Robert Betchov, Raymond Brach, Thomas Cullinane, Howard Demuth, Michael Doria, Vincent Goddard, James Kohn, R. Jeffrey Leake, James Lindell, Gary Long, John Lucey, James Massey, Stuart McComas, Andrew MacFarland, Albert Miller, Bruce Morgan, Edgar Morris, Arthur Quigley, Byron Roberts, Neil Schilmoeller, Thomas Smith, Adolph Strandhagen, Arvind Varma, and Leon Winslow have all contributed; we shall always be indebted to them. A special note of thanks is due to Professor Robert Eikenberry for his excellent review of the FORTRAN material in this book. We also extend our appreciation to our long-suffering secretaries—Janet Tillman, Valerie Flanagan, Kathy Simon, Ella Levee, and Shirley Wills—who have produced a decent product from relatively indecent feedstock. Our appreciation is also extended to our reviewers—W. George Devens, Virginia Polytechnic Institute and State University; Francis J. Jankowski, Wright State University; James M. McNeary, University of Wisconsin; Robert Stratton, Tulsa University; Joseph R. Troxler, Northern Arizona University; and Herbert W. Yankee, Worcester Polytechnic Institute—who have had measurable effects on the final version you hold in your hands. Finally, we would like to acknowledge the support of our wives and children in this endeavor.

TO THE STUDENT

We wish you well on your journey in education. You may decide that engineering is a career for which you are well suited, or you may discover that your talents lie in other fields. Or your involvement in this course may simply be an excursion—undertaken out of curiosity—from a non-engineering field of study. In any event, we hope that your moments spent in reading, studying, analyzing, and exercising the material in this book will be well spent and will afford you insights that will serve you well in the future.

W. J. G.
W. E. B.

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CHAPTER ONE ENGINEERING: THE APPLICATION OF SCIENTIFIC PRINCIPLES