

## PREFACE

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*Introduction to Transportation Engineering* is intended as a text for a one-semester junior- or senior-level introductory course in transportation engineering, taught as part of a civil engineering curriculum. The book contains approximately fifty percent more material than can be covered in a single semester. This was done deliberately, to provide instructors with flexibility in the topics they cover. Some of this material is typically introduced in other courses, such as surveying (horizontal and vertical curve layout and earthwork), statistics, and engineering economy. Material on these topics is not intended to substitute for courses in these areas, but rather to provide students with a review and to demonstrate the application of these subjects to transportation engineering.

An introductory course in transportation engineering must serve the needs of at least three types of students. For most students, who will eventually practice some other civil engineering specialty, it will serve as a familiarization course. For others, who will practice in transportation-related jobs immediately after graduation, it will provide background for entry-level practice in transportation engineering. For still others, it will provide the background needed to pursue graduate studies.

In order to meet the needs of all three types of students, an introductory text needs to cover the basics of both theory and practice, convey a sense of the scope of transportation engineering, and maintain an appropriate balance between breadth and depth of coverage. This book emphasizes the social, economic, and political context of transportation engineering; places major emphasis on important practical topics such as geometric design, layer design for highway pavements, *Highway Capacity Manual* methods, and traffic signal timing; and also emphasizes important theoretical topics such as the fundamental techniques of traffic analysis and the economic theory underlying transportation demand modeling. It also provides overviews of several more specialized topics. These include environmental mitigation design for transportation projects, railroad track design, capacity analysis and traffic control for rail and air transportation, mass transit planning and operations, and specific demand analysis techniques.

The basic approach of the book is intermodal. One of its underlying concepts is that the basic techniques and principles of transportation engineering are of wide application, particularly across modal lines. For practical reasons, the major emphasis is often on highways, but care is taken to show how basic concepts and techniques apply to different modes. This approach is followed in the presentation of material on geometric design in Chapter 4 and the introduction of traffic analysis techniques such as space-time diagrams, queuing analysis, and network analysis in Chapter 8. In the latter case, the strategy is to focus on the techniques themselves, and to present examples (from a variety of modal and operational contexts) that are intended to contribute to the students' understanding of them. The intended result is for students to grasp the underlying principles, and then be able to apply them flexibly in a variety of contexts.

## ORGANIZATION OF THE TEXT

Material in the book is organized as follows: Chapters 1 and 2 serve as an introduction, with a focus on the scope and societal context of transportation engineering. Chapters 3–7 cover topics related to the design of transportation facilities. Chapters 8–12 focus on transportation system operation. Chapters 13–15 cover planning and evaluation of transportation systems. There is no one best order for these topics, and instructors should feel free to cover them whatever order they choose. In certain cases, however, the presentation of material in the later chapters assumes that the reader is familiar with topics presented earlier. Chapter 3 should be covered before Chapter 4. Chapters 8–11 should be covered in the order presented, and Chapter 12 should follow Chapter 8. Section 8.3 should be covered before Sections 13.6 and 13.7. Chapter 7, which deals with mitigation of environmental impacts, is placed where it is because the design of environmental mitigation is an important part of facility design; it is also related to the discussion of environmental impact assessment in Section 15.2, and might equally well be covered in conjunction with that material.

## PEDAGOGY

Because experience shows that many students learn best by example, efforts have been made to provide numerous example problems and student exercises. Student exercises include written exercises, homework problems, computer exercises, and open-ended design exercises. Written exercises include both short answer questions and suggested term paper topics. As a general rule, homework problems include several versions of what is essentially the same problem. These are intended to provide instructors with flexibility in assigning problems, and to accommodate students who wish to gain extra practice by working several versions of the same problem. Computer exercises include both programming exercises, which require knowledge of FORTRAN or similar languages, and spread sheet exercises. A solutions manual has been provided for instructors; it contains solutions to the homework problems, answers for the short-answer written exercises, FORTRAN code for the programming exercises, and Excel spread sheets for the spread sheet exercises.

**New Design Exercises.** Design exercises are a major new feature of the second edition. These exercises introduce students to the thought processes and documentation involved in a variety of types of transportation design. They are intended to be relatively simple and straightforward and thus to serve as easily-documented introductory steps in a process that integrates design throughout the professional component of the curriculum, as required by the ABET civil engineering program criteria.

Every effort has been made to present up-to-date material. This includes reference to recent research related to speed-flow-density relationships for highway traffic, use of *Highway Capacity Manual 2000*, and use of metric design standards from the 1994 edition of the *AASHTO Policy on Geometric Design of Highways and Streets*. Metri- cation continues to pose a special problem because the United States is still in transition between traditional and metric units. The book reflects this state of transition; the

system used for primary units is typically metric, but is occasionally traditional, depending on the usage of the principle references for the topic. Equivalent units for the other system are given in parentheses. The primary system of units for highway geometric design is metric, following the 1994 AASHTO *Policy*. In the case of highway capacity, the text of the second edition follows the metric version of *Highway Capacity Manual 2000*, but tables and figures from the U.S. customary unit version are included in an appendix to accommodate instructors who prefer them.

## ACKNOWLEDGMENTS

This book began as a set of course notes that other instructors and I had developed at the University of California at Berkeley in the mid-1970s. Over the years, these notes were used at San Diego State University, California State University, Chico, and possibly other campuses in California. During this period, these notes were expanded and revised with contributions from a number of authors, including Thomas C. Ferrara, A. Reed Gibby, and several of their students at Cal State Chico, as well as myself. In 1994, I completely revised this material to turn what had previously been a disconnected set of course notes into a connected work. This was subsequently revised and expanded to produce the first edition of this book, which serves as the basis for this edition. In converting the original set of course notes into a book, I drew on several articles, otherwise unpublished, that were included in the course notes. I wish to acknowledge a particular debt to articles on various aspects of geometric design by V. F. Hurdle, an article on highway pavements by Thomas C. Ferrara, and an article on the use of mass diagrams in earthwork computations developed from material written by Prof. F. S. Foote.

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James H. Banks  
San Diego State University