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# INTRODUCTION TO ENVIRONMENTAL ENGINEERING

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**Mackenzie L. Davis**

*Michigan State University*

**David A. Cornwell**

*Environmental Engineering and Technology*

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## **INTRODUCTION TO ENVIRONMENTAL ENGINEERING**

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## ABOUT THE AUTHORS

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**Mackenzie L. Davis** is an Associate Professor of Environmental Engineering at Michigan State University. He received all his degrees from the University of Illinois. From 1968 to 1971 he served as a Captain in the U.S. Army Medical Service Corps. During his military service he conducted air pollution surveys at Army ammunition plants. From 1971 to 1973 he was Branch Chief of the Environmental Engineering Branch at the U.S. Army Construction Engineering Research Laboratory. His responsibilities included supervision of research on air, noise, and water pollution control and solid waste management for Army facilities. In 1973 he joined the faculty at Michigan State University. He teaches and conducts research in the areas of air pollution control and hazardous waste management.

In 1987 and 1989–90, under an Intergovernmental Personnel Assignment with the Office of Solid Waste of the U.S. Environmental Protection Agency, Dr. Davis performed technology assessments of treatment methods used to demonstrate the regulatory requirements for the land disposal restrictions (“land ban”) promulgated under the Hazardous and Solid Waste Amendments.

Dr. Davis is a member of the following professional organizations: American Chemical Society; American Institute of Chemical Engineers; American Meteorological Society; American Society of Civil Engineers; Air & Waste Management Association; Association of Environmental Engineering Professors; and the Water Pollution Control Federation. Currently, he serves on the editorial review board of the *Journal of the Air & Waste Management Association*.

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To our students,  
who make it worthwhile

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## PREFACE

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This text is for use in an introductory sophomore level engineering course. It is written in a language and style that will appeal to sophomores. (Some pundits claim it is puerile; we claim that it is at least sophomoric.) We assume that the book will be used in one of the first engineering courses encountered by the student. Over the 36 offerings of the course material in this format, we have found that mature college seniors in allied fields—such as biology, chemistry, resource development, fisheries and wildlife, microbiology, and soils science—have no difficulty with the material. Likewise, we suspect that any bright science/mathematics-oriented high school senior would find the material easy to master. Senior level engineering students will find the material a snap, and perhaps beneath their dignity.

We have emphasized concepts, definitions, descriptions, abundant illustrations (to the horror of our beloved publisher), and a tad of humor. In the mathematical presentations we have provided only a few derivations. Engineering professors will complain (it must be confessed with justice) of insufficient rigor. But to this question there are two sides; however important it may be to maintain a uniformly high standard in pure mathematics, the engineering professional may occasionally do well to rest content with the result of the argument. To our minds, the more stringent procedures of the pure mathematician may yield a result that is not more but less demonstrative—and even confusing—to the beginning engineering student. And to insist on the highest standard would mean exclusion of many important subjects altogether in view of the space that would be required.

Two themes are carried through the text. The first is an introduction to the concept of mass balance as a tool for problem solving. The concept is introduced in the first chapter and then applied for conservative systems in hydrology (hydrologic cycle, development of the rational formula, and reservoir design). This theme is expanded to include chemical reaction kinetics, reactor design, and sludge mass balance in Chapter 3. The DO sag curve is developed using a mass balance approach. The design equations for a completely mixed activated sludge system

and a more elaborate sludge mass balance are developed in Chapter 5. Mass balance is used to account for the production of sulfur dioxide from the combustion of coal and in the development of absorber design equations in Chapter 6. In Chapter 9, a mass balance approach is used for waste audit.

The second theme is the concept that pollution control begins with the minimization of the generation waste. This is introduced in Chapter 2 under the heading of water conservation. It is addressed again in the sludge management section of the water treatment chapter, in air pollution control, resource conservation and recovery in solid waste management, and the reduction of hazardous waste generation rates.

A solution manual and computer disk are available for qualified instructors. Please inquire with your McGraw-Hill representative. We appreciate any comments, suggestions, corrections, and contributions of problems for future revisions.

As it stands in the curriculum at Michigan State University, the course bearing the title of this book provides the foundation for four follow-on senior level environmental engineering courses. We believe in and support the philosophy of the Association of Environmental Engineering Professors that the undergraduate environmental engineering curriculum must be expanded if we are to maintain modern, rigorous graduate programs. The fact that our better high schools provide opportunities for first-year calculus and college level chemistry, physics, and computer courses allows us to push advanced undergraduate courses down to the introductory level. And we can thus push introductory graduate courses into the undergraduate curriculum to make room for more advanced and more rigorous graduate courses. If future generations are to advance our civilization and redeem the sins of their forbears, this must be done.

## ACKNOWLEDGMENTS

As with any other text, the number of individuals who have made it possible far exceeds those whose names grace the cover. At the hazard of leaving someone out, we would like to explicitly thank the following individuals for their contribution.

First and foremost we want to thank Ann Greenfield and Vicki Switzer, who did the bulk of the typing. In addition, the following individuals also have put their fingers to the keyboard in our behalf: Sherri Rich, Jodi Doerner, Nancy Hunt, Kathy Haller, and Sue Smith. Linda Clowater and Elizabeth Fry converted the original typed manuscript to computer format.

The following students helped to solve problems, proofread text, prepare illustrations, raise embarrassing questions, and generally make sure that other students could understand it: Deb Allen, Mark Bishop, Jeff Brown, Kristen Brandt, Linda Clowater, John Cooley, Ted Coyer, Marcia Curran, Kimberly Doherty, Craig Fricke, Elizabeth Fry, Kathy Hulley, Edith Hooten, Angela Ilieff, Gary Lefko, Lynelle Marolf, Lisa McClanahan, Tim McNamara, Becky Mursch, Cheryl Oliver, Jim Peters, Bob Reynolds, Laurene Rhyne, Sandra Risley, Lee Sawatzki, Mary Stewart, and Rick Wirsing. To them a hearty thank you!

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And last, but certainly not least, we wish to thank our families, who have put up with the nonsense of book writing.

*Mackenzie L. Davis*  
*David A. Cornwell*

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