PEARSON Education

电工学——原理与应用

第3版　影印版

Electrical Engineering

Principles and Applications 3/e

Allan R. Hambley

高等教育出版社

电工学——原理与应用

第3版　影印版

Electrical Engineering Principles and Applications 3/e

Allan R. Hambley

高等教育出版社

图字:01 - 2005 - 5365 号

图书在版编目(CIP)数据

电工学:原理与应用 = Electrical Engineering Principles and Applications:第 3 版/(美)汉布利(Hambley, A. R.). —影印本. —北京:高等教育出版社,2005.12
ISBN 7 - 04 - 018567 - 9

Ⅰ.电... Ⅱ.汉... Ⅲ.电工学—英文 Ⅳ.TM1

中国版本图书馆 CIP 数据核字(2005)第 146146 号

策划编辑 刘激扬 **责任编辑** 韩 颖 **封面设计** 刘晓翔 **责任印制** 陈伟光

出版发行	高等教育出版社	**购书热线**	010 - 58581118
社 址	北京市西城区德外大街 4 号	**免费咨询**	800 - 810 - 0598
邮政编码	100011	**网 址**	http://www.hep.edu.cn
总 机	010 - 58581000		http://www.hep.com.cn
		网上订购	http://www.landraco.com
			http://www.landraco.com.cn
经 销	蓝色畅想图书发行有限公司	**畅想教育**	http://www.widedu.com
印 刷	北京民族印刷厂		
开 本	889 × 1194 1/16	**版 次**	2005 年 12 月第 1 版
印 张	56.5	**印 次**	2005 年 12 月第 1 次印刷
字 数	1 000 000	**定 价**	69.00 元

本书如有缺页、倒页、脱页等质量问题,请到所购图书销售部门联系调换。

物料号 18567 - 00

序　言

与上两版本一样，本书的编写指导思想主要有以下三点：第一，长远来看，学生应学好基本概念；其次，通过应用实例来激发学生的学习热情，第三，尽可能使学生避免学习挫折。

本书包括电路分析、数字系统、电子学和电机，适用于电气工程学生的专业导论课程或非电专业学生的概论课程。先修课程只需要基础物理学和单变量微积分。本书主要内容包括：

- 基本电路分析和测量
- 一阶和二阶电路的瞬态响应
- 交流稳态电路
- 谐振和频率响应
- 数字逻辑电路
- 微控制器(68HC11)
- 基本计算机的测量仪器(含 LabVIEW)
- 二极管电路
- 放大电路
- 场效应晶体管和双极型晶体管
- 运算放大器
- 变压器
- 交流电机和直流电机
- 计算机辅助电路分析(PSpice)

本书注重基本概念，每一部分都安排一段概括电气工程概念在其他领域的应用，包括内燃机中的抗震信号处理、心脏起搏器、动态噪音控制、全球定位系统(GPS)等等。

非常欢迎本书的使用者提出宝贵建议，有关本书改进的建议尤其有价值，而且将会体现在修订版中，我的电子邮件地址是 arhamble@ mtu. edu.

软　件

本书附有二张光盘，一张为学生版 LabVIEW 7，在 9.4 中将简略介绍其使用方法。LabVIEW 现已经成为工程仪器和测量的工业标准软件包，我们试图让学生学会用 LabVIEW、个人电脑和数据采集卡快速构建特殊用途的仪器和控制系统，为他们今后进一步开始计算机辅助仪器技术打下基础。

第二张光盘是 OrCAD9.2 家庭精简版，这是 Cadence System 公司开发的电路分析和设计的一组功能强大的程序。附录 D 介绍了如何建立电路及设置分析，其中 PSpice 用于分析电路，Probe 用于观察结果。从第 2 章开始，全书选择了大量电路作为分析实例。学生们将会发现，计算机辅助分析是扩展他们对电路感性认识的一个非常有效的方法，也是检查答题结果的一个很好的手段。

除了提供评估版软件，本书涉及的虚拟仪器(LabVIEW 程序)和电路文件都包含在 OrCAD 光盘内。此外，每章练习解答、部分章末问题答案和各章的主要公式汇集也以 pdf 格式文件包含在 OrCAD 光盘之中。

第三版的变化及新特征

- 提供具有全部功能的工业标准仪器软件学生版 LadVIEW 7，可供学生在后续课程中使用。
- 每章的章末问题都几乎增加了百分之二十以上。
- 为增强阅读性，全书作了多处修改并添加了一些内容。

■ 第 1 章增加了一个利用 KVL、KCL 和欧姆定律分析电路的例子。
■ 6.5 节增加了利用 MATLAB 画 Bode 图的介绍。
■ 第 9 章增加了一个传感器负载的例子，LabVIEW 的相关内容也作了更新。
■ 增加了“实际应用 9.1 虚拟一攻线”
■ 增加了“实际应用 11.1 电子图钉探测器”，说明电工理论的应用。
■ 删除了第 11 章的平衡电路设计。
■ 重新组织了第 14 章运算放大器，在反相放大器分析中引入了求和点约束。
■ 增加了 16.7 直流发电机。
■ 第 17 章增加了无刷直流电机。
■ 教师手册提供了附录 A 和 C 中的练习及问题解答，同时在 OrCAD 光盘上提供给学生参考。

先修课程

本书的先修课程是基础物理学和单变量微积分学，先修微分方程课程对学习本课程会有帮助，但不是必要的。微分方程将在第 4 章瞬态分析中用到，但是所需的基础可以从基本微积分学导出。

教学特点

本书包括多种激发学生兴趣、避免概念混淆和指导学生择业的材料，符合教学特点，包括：

■ 每章开始有一段关于学习目的叙述。
■ 在页边空白处，总结、强调要点或需要避免常见错误。
■ 用加框文字给出电工理论在其他工程领域的应用，例如，动态噪音消除（第 263 页）和心脏起搏器（364 页开始）。
■ 解题过程循序渐进，例如，节点电压分析的一步一步总结（72 ~ 73 页）及戴维宁等效的归纳（88 页）。
■ 在 OrCAD 光盘上提供每章练习的全部解答（pdf 文件），供学生学习时参考。
■ 大约四分之一的章末问题答案也以 pdf 文件格式在 OrCAD 光盘中提供给学生，帮助学生建立信心并指导学生课外阅读。
■ 每章结束给出重点摘要，供学生参考。
■ 重要公式在书中用黑体给出并以 pdf 格式文件在 OrCAD 光盘提供给学生，以便快速、方便地检索。

满足认证培训教学需求

本书可为多种授权证书培训提供很好选择，标准工程认证（Criteria for Accrediting Engineering Programs）要求，毕业生应有“应用数学、科学和工程知识的能力”和“认识、表述和解决工程问题的能力。”本书的目的正是为培养学生这些能力而编写的。

同时，毕业生必须有“设计、组织实验及分析和解释数据的能力。”第 9 章基于计算机的仪器系统就是旨在培养这一能力，若课程包含实验，则该方面能力可得到进一步培养。

此外，标准要求“团队协作的能力”和“有效沟通的能力。”基于本书的课程为非电类专业学生提供相关知识及有效地与电气工程师沟通的能力训练。本书也帮助电气工程师了解电工理论在其他工程领域的应用，为了加强交流，每章的章末问题要求学生以他们自己的语言来解释电气工程概念。

本书所附的 LabVIEW 和 OrCAD PSpice 软件包可作为培养“使用技术、技能和现代工程必备工具进行工程实践能力”的一个手段。

解答手册及网站

学生能在 OrCAD 光盘和网站上找到每章练习解答和部分章末问题答案（不含解答过程）。

本书勘误的信息和解答手册将会在网站上公布，本书主页为 http://www.prenhall.com/hambley

教师资源

网站上也包含各种教师资源：

- PowerPoint 演示稿
- Syllabus Builder™
- Word 格式和 pdf 格式的教师手册

此外，出版社可为采用本书的教师提供印刷的完整解答手册。

目录及内容组织

Part Ⅰ 电路

第 1 章定义电流、电压、功率和能量，介绍基尔霍夫定律，定义电压源、电流源和电阻。

第 2 章研究电阻电路，介绍网络化简、节点电压和网孔电流分析法，介绍戴维宁等效、叠加定理和惠斯通电桥。

第 3 章介绍电容、电感和互感。

第 4 章讨论电路的瞬态响应，首先介绍一阶 RL 和 RC 电路和时间常数，然后讨论二阶电路。

第 5 章讨论正弦稳态电路，介绍功率计算、交流电路戴维宁和诺顿等效、对称三相电路，附录 A 为复数运算的复习。

第 6 章讨论频率响应、Bode 图、谐振、滤波器和数字信号处理，初步建立傅立叶理论（信号由具有各种不同幅度、相位和频率的正弦成份组成）的基本概念。

Part Ⅱ 数字系统

第 7 章介绍逻辑门、二进制数值表达、组合逻辑和时序逻辑，讨论布尔代数、摩根定律、真值表、卡诺图，编码器、译码器、触发器和寄存器。

第 8 章以摩托罗拉 68HC11 为例重点讨论嵌入式系统的微型计算机，介绍计算机结构和存储器类型。概述使用微控制器的数字处理控制，最后，简单介绍 68HC11 的指令系统和寻址模式，非常简要地介绍汇编语言编程。

第 9 章讨论基于计算机的测量系统，包括测量概念、传感器、信号调理和模拟 - 数字转换。章末讨论 LabVIEW，包含学生可复制到自己计算机上学生版中使用的虚拟仪器。

Part Ⅲ 电子学

第 10 章介绍二极管及其电路模型、负载线分析和二极管电路，如整流电路、稳压管稳压电路和波形形成电路。

第 11 章从应用的角度讨论放大电路的性能参数和缺陷，包括增益、输入阻抗、输出阻抗、负载效应、频率响应、脉冲响应、非线性失真、共模抑制和直流偏移。

第 12 章介绍 MOS 场效应晶体管及其特性曲线、负载线分析、大信号和小信号模型、偏置电路、共源放大电路和源极跟随器。

第 13 章类似地介绍双极型晶体管，如需要，第 12 和 13 章的次序可颠倒，另一种选择是略去这两章的大部分内容，而将更多时间用于其他主题。

第 14 章讨论运算放大器及其应用，非电类专业学生能从本章学习如何使用和设计用于各自领域测量仪器的运算放大器电路。

Part Ⅳ 电机

第 15 章复习磁场基本理论、磁路分析，介绍变压器。

第 16 和 17 章分别讨论直流电机和交流电机，因为非电气工程师更多是使用电动机，所以重点介绍电动

机而不是发电机，第16章在讨论直流电机之前，首先介绍电动机原理及其等效电路和特性计算，讨论原型电动机及其应用。

第17章从三相感应电动机开始讨论交流电动机，分析同步电机及其对功率因数矫正的优势。同时讨论了单相感应电动机等小型电动机，本章最后介绍了步进电机和无刷直流电机。

鸣谢

感谢我在密西根理工大学(Michigan Technological University)电气与计算机工程系过去和现在的同事们在我编写本书和其它项目中不断给予我帮忙和鼓励。

感谢国家仪器公司的Jim Cahow、Ravi Marawar博士、John Wilson和Kathy Brown为本书提供了LabVIEW学生版使用许可及本书的图形图像等其它材料。感谢Tim Christensen为本书提供OrCAD9.2精简版的使用许可。

在我编写本书的各个阶段，收到其它学院的审稿教授们许多很好的建议，这些建议使终稿得到非常大的改善，我对他们的帮助表示感谢。第一版的审稿人有：

Drexel University的Edwin L. Gerber；

University of Toronto的Belinda B. Wang；

Texas Tech University的Edgar A. O'Hair；

Texas A & M University的Phil Noe；

Syracuse University的Joseph A. Coppola；

University of Colorado, Colorado Springs的Rodger E. Ziemer；

University of Houston的Len Trombetta；

Washington State University的Carl Wells；

Rutgers University的Zoran Gajic；

University of Wisconsin的Richard S. Marleau；

Case Western University的Robert Collin；

North Carolina State University的W. T. Easier；

Iowa State University的John Pavlat；

Columbia University的Edward Yang；

Northwestern University的Ibrahim Abdel-Motaled；

Cornell University的Clifford Pollock；

Montana State University的Victor Gerez；

Georgia Institute of Technology的William Sayle II；

Carnegie Mellon University的Michael Reed；

Michigan Technological University的D. B. Brumm；

Texas Tech University的Sunanda Mitra；

New Mexico Highlands University的Elmer Grubbs；

感谢审阅了第二版原稿并提出很好改进建议的Virginia Tech教授Al Wicks。

多年来，Michigan Technological University和其他使用本书的许多学生和教员给我提出了许多非常好的修改建议与错误矫正，对此，我表示衷心的感谢。

非常感谢Prentice Hall的本书编辑Tom Robbins，是他给了我正确的编写方向并给了我许多很好的建议，感谢Scott Disanno为本书出版所作的大量事务性工作。

同时，我还要感谢Tony和Pam一直以来对我的鼓励和真知灼见，感谢Judy为我所作的难以列举的众多好事。

ALLAN R. HAMBLEY

Preface

As in the previous editions, my guiding philosophy in writing this book has three elements. The first element is my belief that in the long run students are best served by learning basic concepts in a general setting. Second, I believe that students need to be motivated by seeing how the principles apply to specific and interesting problems in their own fields. The third element of my philosophy is to take every opportunity to make learning free of frustration for the student.

This book covers circuit analysis, digital systems, electronics, and electromechanics at a level appropriate for either electrical-engineering students in an introductory course or nonmajors in a survey course. The only essential prerequisites are basic physics and single-variable calculus. Teaching a course using this book offers opportunities to develop theoretical and experimental skills and experiences in the following areas:

- Basic circuit analysis and measurement
- First- and second-order transients
- Steady-state ac circuits
- Resonance and frequency response
- Digital logic circuits
- Microcontrollers (68HC11)
- Computer-based instrumentation, including LabVIEW
- Diode circuits
- Electronic amplifiers
- Field-effect and bipolar junction transistors
- Operational amplifiers
- Transformers
- Ac and dc machines
- Computer-aided circuit analysis (PSpice)

While the emphasis of this book is on basic concepts, a key feature is the inclusion of short articles scattered throughout showing how electrical-engineering concepts are applied in other fields. The subjects of these articles include anti-knock signal processing for internal combustion engines, a cardiac pacemaker, active noise control, and the use of the Global Positioning System in surveying, among others.

I welcome comments from users of this book. Information on how the book could be improved is especially valuable and will be taken to heart in future revisions. My e-mail address is arhamble@mtu.edu

SOFTWARE

Two CDs are included with this book. One contains the student version of LabVIEW 7 Express, which is briefly discussed in Section 9.4. LabVIEW has become the industry standard software package for engineering instrumentation and testing. The intention is to make students aware of how LabVIEW coupled with a personal computer and a data acquisition board can be used to rapidly create special-purpose instrumentation and control systems. Later, when they have the need to design such systems, they will have enough knowledge to establish a proper direction for further development of their computer-aided instrumentation skills.

The second CD contains OrCAD Family Release 9.2 Lite Edition. This is a powerful suite of programs produced by Cadence Systems for circuit analysis and design. In Appendix D, we show how to use Capture for entering circuit diagrams and setting up analyses, PSpice for analyzing the circuit, and Probe for viewing results. A number of circuits selected from throughout the book, starting in Chapter 2, are taken as examples. Students find computer-aided analysis to be an effective method for extending their "feel" for circuits and for checking some of the answers obtained through traditional analysis.

Besides the evaluation programs, the virtual instruments (LabVIEW programs) and circuit files discussed in the book are included on the OrCAD CD. Furthermore, solutions to the in-chapter exercises, answers for selected end-of-chapter problems, and summaries of key equations for each chapter are included in pdf files on the OrCAD CD.

CHANGES AND NEW FEATURES IN THE THIRD EDITION

- The Student Edition of LabVIEW 7 Express is included with the book, providing students with a full featured version of this industry-standard instrumentation software that they can use in subsequent courses.
- End-of-chapter problems have been added to nearly every chapter, increasing the total number by over twenty percent.
- Numerous changes and additions have been made throughout the book to enhance clarity.
- A new example using KVL, KCL, and Ohm's Law to solve a circuit has been added to Chapter 1.
- A discussion of computer generated Bode plots utilizing MATLAB has been added to Section 6.5.
- An example on sensor loading has been added to Chapter 9 and the section on LabVIEW has been updated.
- Practical Application 9.1 The Virtual First Down Line has been added.
- Practical Application 11.1 Electronic Stud Finder has been added to illustrate the use of several electrical-engineering principles.
- The discussion of balance-circuit design has been deleted from Chapter 11.

- Chapter 14 Operational Amplifiers has been reorganized, absorbing the discussion of summing-point constraint into the section on inverting amplifiers.
- Section 16.7 DC Generators has been added.
- A discussion of brushless dc machines has been added to Chapter 17.
- Solutions for the exercises and problems in Appendices A and C are now provided in the instructor's Solutions Manual and on the OrCAD CD for student reference.

PREREQUISITES

The essential prerequisites for a course from this book are basic physics and single-variable calculus. A prior differential equations course would be helpful but is not essential. Differential equations are encountered in Chapter 4 on transient analysis, but the skills needed are developed from basic calculus.

PEDAGOGICAL FEATURES

The book includes various pedagogical features designed with the goal of stimulating student interest, eliminating frustration, and engendering an awareness of the relevance of the material to their chosen profession. These features are:

- Statements of learning objectives open each chapter.
- Comments in the margins emphasize and summarize important points or indicate common pitfalls that students need to avoid.
- Short boxed articles demonstrate how electrical-engineering principles are applied in other fields of engineering. For example, see the articles on active noise cancellation (page 263) and electronic pacemakers (starting on page 364).
- Step-by-step problem solving procedures. For example, see the step-by-step summary of node-voltage analysis (on pages 72–73) or the summary of Thévenin equivalents (on page 88).
- Complete solutions to the in-chapter exercises included as pdf files on the OrCAD CD provide students with help.
- Answers to approximately one-quarter of the end-of-chapter problems, provided as pdf files on the OrCAD CD, build student confidence and indicate where additional study is needed.
- Summaries of important points at the end of each chapter provide references for students.
- Key equations highlighted in the book and included as pdf files on the OrCAD CD provide quick and convenient references for students.

MEETING ABET-DIRECTED OUTCOMES

Courses based on this book provide excellent opportunities to meet many of the directed outcomes for accreditation. The Criteria for Accrediting Engineering Programs require that graduates of accredited programs have "an ability to apply knowledge of mathematics, science, and engineering" and "an ability to identify, formulate, and solve engineering problems." This book, in its entirety, is aimed at developing these abilities.

Also, graduates must have "an ability to design and conduct experiments, as well as analyze and interpret data." Chapter 9, Computer-Based Instrumentation Systems, helps to develop this ability. If the course includes a laboratory, this ability can be developed even further.

Furthermore, the criteria require "an ability to function on multi-disciplinary teams" and "an ability to communicate effectively." Courses based on this book contribute to these abilities by giving nonmajors the knowledge and vocabulary to communicate effectively with electrical engineers. The book also helps to inform electrical engineers about applications in other fields of engineering. To aid in communication skills, end-of-chapter problems that ask students to explain electrical-engineering concepts in their own words are included.

The LabVIEW and OrCAD PSpice software packages distributed with this book contribute to developing "an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice."

SOLUTIONS MANUAL AND WEBSITE

Students can find solutions for the in-chapter exercises and answers (without solutions) for selected end-of-chapter problems on the OrCAD CD included with the book and on the website.

Any corrections that may be needed for the book or solutions manual will be posted on the website as they are found. The home page for this book is located at http://www.prenhall.com/hambley

INSTRUCTOR RESOURCES

The website also contains resources for instructors including:

- PowerPoint lecture slides
- Syllabus Builder™
- Instructor's Solutions Manual in Word and pdf formats

Furthermore, a complete solutions manual is available in hard copy from the publisher to instructors who have adopted the book.

CONTENT AND ORGANIZATION

Part I Circuits

Chapter 1 defines current, voltage, power, and energy. Kirchhoff's laws are introduced. Voltage sources, current sources, and resistance are defined.

Chapter 2 treats resistive circuits. Analysis by network reduction, node voltages, and mesh currents is covered. Thévenin equivalents, superposition, and the Wheatstone bridge are treated.

Capacitance, inductance, and mutual inductance are treated in Chapter 3.

Transients in electrical circuits are discussed in Chapter 4. First-order *RL* and *RC* circuits and time constants are covered, followed by a discussion of second-order circuits.

Chapter 5 considers sinusoidal steady-state circuit behavior. (A review of complex arithmetic is included in Appendix A.) Power calculations, ac Thévenin and Norton equivalents, and balanced three-phase circuits are treated.

Chapter 6 covers frequency response, Bode plots, resonance, filters, and digital signal processing. The basic concept of Fourier theory (that signals are composed of sinusoidal components having various amplitudes, phases, and frequencies) is qualitatively discussed.

Part II Digital Systems

Chapter 7 introduces logic gates and the representation of numerical data in binary form. It then proceeds to discuss combinatorial and sequential logic. Boolean algebra, De Morgan's laws, truth tables, Karnaugh maps, coders, decoders, flip flops, and registers are discussed.

Chapter 8 treats microcomputers with emphasis on embedded systems using the Motorola 68HC11 as the primary example. Computer organization and memory types are discussed. Digital process control using microcontrollers is described in general terms.. Finally, selected instructions and addressing modes for the 68HC11 are described. Assembly language programming is treated very briefly.

Chapter 9 discusses computer-based instrumentation systems including measurement concepts, sensors, signal conditioning, and analog-to-digital conversion. The chapter ends with a discussion of LabVIEW, including an example virtual instrument that students can duplicate using the included student version on their own computers.

Part III Electronics

Chapter 10 presents the diode, its various models, load-line analysis, and diode circuits, such as rectifiers, Zener-diode regulators, and wave shapers.

In Chapter 11, the specifications and imperfections of amplifiers that need to be considered in applications are discussed from a users perspective. These include gain, input impedance, output impedance, loading effects, frequency response, pulse response, nonlinear distortion, common-mode rejection, and dc offsets.

Chapter 12 covers the MOS field-effect transistor, its characteristic curves, load-line analysis, large-signal and small-signal models, bias circuits, the common-source amplifier, and the source follower.

Chapter 13 gives a similar treatment for bipolar transistors. If desired, the order of Chapters 12 and 13 can be reversed. Another possibility is to skip most of both chapters so more time can be devoted to other topics.

Chapter 14 treats the operational amplifier and many of its applications. Non-majors can learn enough from this chapter to design and use op-amp circuits for instrumentation applications in their own fields.

Part IV Electromechanics

Chapter 15 reviews basic magnetic field theory, analyzes magnetic circuits, and presents transformers.

Dc machines and ac machines are treated in Chapters 16 and 17, respectively. The emphasis is on motors rather than generators because the nonelectrical engineer applies motors much more often than generators. In Chapter 16, an overall view of motors in general is presented before considering dc machines, their equivalent circuits, and performance calculations. The universal motor and its applications are discussed.

Chapter 17 deals with ac motors, starting with the three-phase induction motor. Synchronous motors and their advantages with respect to power-factor correction are analyzed. Small motors including single-phase induction motors are also discussed. A section on stepper motors and brushless dc motors ends the chapter.

ACKNOWLEDGMENTS

I wish to thank my colleagues, past and present, in the Electrical and Computer Engineering Department at Michigan Technological University, all of whom have given me help and encouragement at one time or another in writing this book and in my other projects.

I also thank Jim Cahow, Dr. Ravi Marawar, John Wilson, and Kathy Brown at National Instruments who have been most helpful in providing permission to distribute the student version of LabVIEW, photographs, and other material for this book. I also thank Tim Christensen of OrCAD for providing permission to distribute OrCAD Lite 9.2 with the book.

I have received much excellent advice from professors at other institutions who reviewed the manuscript in various stages. This advice has improved the final result a great deal, and I am grateful for their help. The reviewers for the first edition were:

Edwin L. Gerber, Drexel University;
Belinda B. Wang, University of Toronto;
Edgar A. O'Hair, Texas Tech University;
Phil Noe, Texas A & M University;
Joseph A. Coppola, Syracuse University;
Rodger E. Ziemer, University of Colorado, Colorado Springs;

Len Trombetta, University of Houston;
Carl Wells, Washington State University;
Zoran Gajic, Rutgers University;
Richard S. Marleau, University of Wisconsin;
Robert Collin, Case Western University;
W.T. Easter, North Carolina State University;
John Pavlat, Iowa State University;
Edward Yang, Columbia University;
Ibrahim Abdel-Motaled, Northwestern University;
Clifford Pollock, Cornell University;
Victor Gerez, Montana State University;
William Sayle II, Georgia Institute of Technology;
Michael Reed, Carnegie Mellon University;
D. B. Brumm, Michigan Technological University;
Sunanda Mitra, Texas Tech University;
Elmer Grubbs, New Mexico Highlands University.

I also thank Professor Al Wicks of Virginia Tech who reviewed the manuscript for the second edition and supplied excellent suggestions for improvement.

Over the years, many students and faculty using my books at Michigan Technological University and elsewhere have made many excellent suggestions for improving the books and correcting errors. I thank them very much.

I am indebted to Tom Robbins, my editor at Prentice Hall, for keeping me pointed in the right direction and for many excellent suggestions that have improved my books a great deal. Thanks, also, to Scott Disanno for a great job of managing the production of this book.

Also, I want to thank Tony and Pam for their continuing encouragement and valuable insights. I thank Judy for many good things too extensive to list.

ALLAN R. HAMBLEY

List of Examples

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

Chapter 15

Chapter 16

Chapter 17

Appendix A