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Basic Engineering Circuit Analysis 7e

工程电路分析基础（第7版）

J. David Irwin

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Basic Engineering Circuit Analysis

Seventh Edition

A Wiley First Edition

J. David Irwin

AUBURN UNIVERSITY

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J. David Irwin
Basic Engineering Circuit Analysis, 7th Edition

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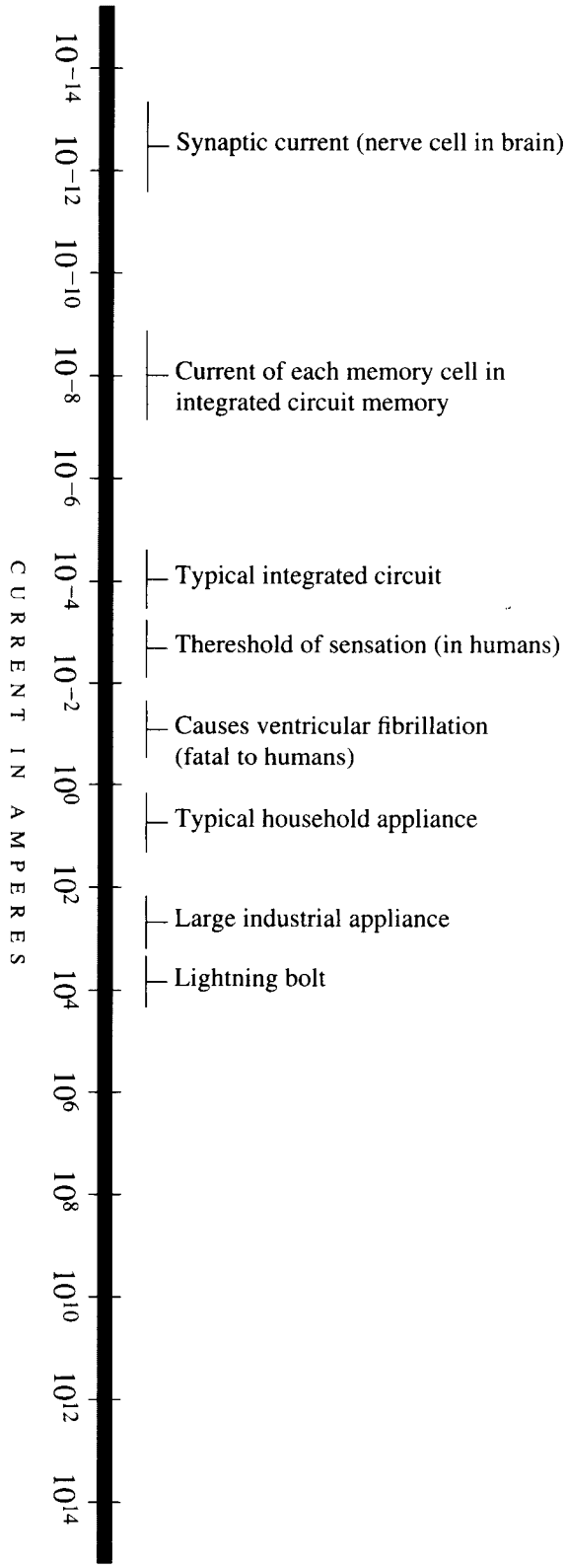

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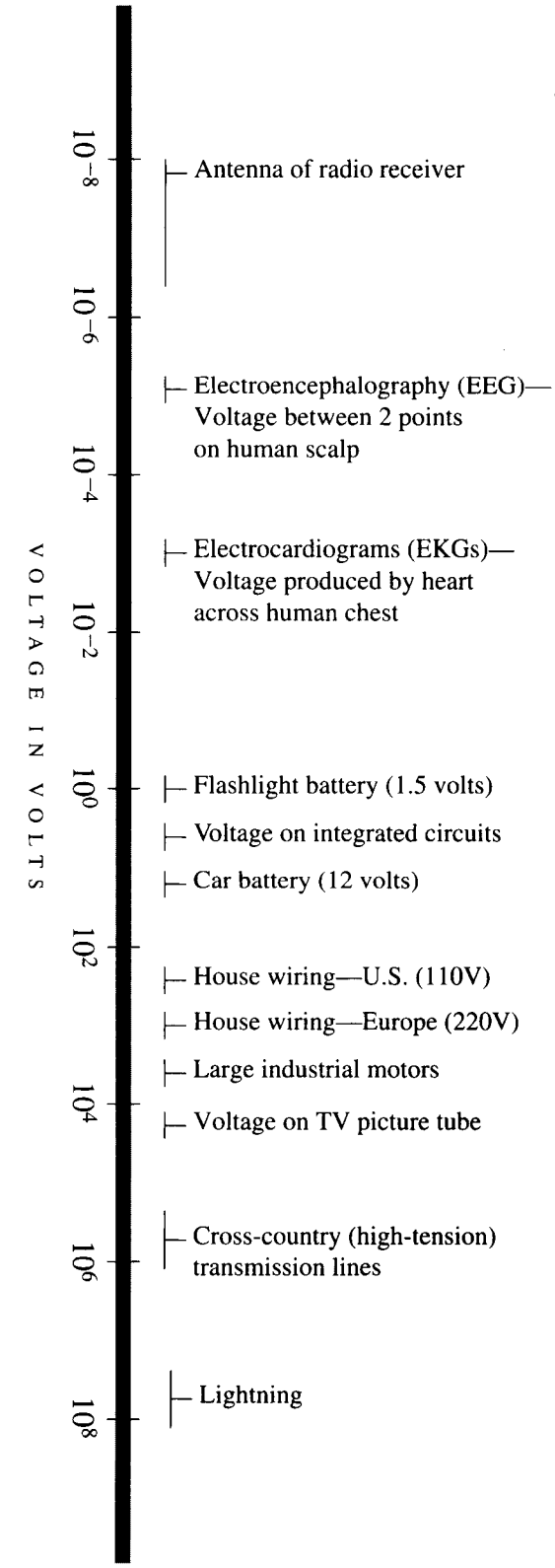

国际知名大学原版教材

——信息技术学科与电气工程学科系列

出 版 说 明

郑大钟
清华大学信息科学与技术学院

当前，在我国的高等学校中，教学内容和课程体系的改革已经成为教学改革中的一个非常突出的问题，而为数不少的课程教材中普遍存在的“课程体系老化，内容落伍时代，本研层次不清”的现象又是其中的急需改变的一个重要方面。同时，随着科教兴国方针的贯彻落实，要求我们进一步转变观念扩大视野，使教学过程适应以信息技术为先导的技术革命和我国社会主义市场经济体制的需要，加快教学过程的国际化进程。在这方面，系统地研究和借鉴国外知名大学的相关教材，将会对推进我们的课程改革和推进我国大学教学的国际化进程，乃至对我们一些重点大学建设国际一流大学的努力，都将具有重要的借鉴推动作用。正是基于这种背景，我们决定在国内推出信息技术学科和电气工程学科国外知名大学原版系列教材。

本系列教材的组编将遵循如下的几点基本原则。(1)书目的范围限于信息技术学科和电气工程学科所属专业的技术基础课和主要的专业课。(2)教材的范围选自于具有较大影响且为国外知名大学所采用的教材。(3)教材属于在近 5 年内所出版的新书或新版书。(4)教材适合于作为我国大学相应课程的教材或主要教学参考书。(5)每本列选的教材都须经过国内相应领域的资深专家审看和推荐。(6)教材的形式直接以英文原版形式印刷出版。

本系列教材将按分期分批的方式组织出版。为了便于使用本系列教材的相关教师和学生从学科和教学的角度对其在体系和内容上的特点和特色有所了解，在每本教材中都附有我们所约请的相关领域资深教授撰写的影印版序言。此外，出于多样化的考虑，对于某些基本类型的课程，我们还同时列选了多于一本的不同体系、不同风格和不同层次的教材，以供不同要求和不同学时的同类课程的选用。

本系列教材的读者对象为信息技术学科和电气工程学科所属各专业的本科生，同时兼顾其他工程学科专业的本科生或研究生。本系列教材，既可采用作为相应课程的教材或教学参考书，也可提供作为工作于各个技术领域的工程师和技术人员的自学读物。

组编这套国外知名大学原版系列教材是一个尝试。不管是书目确定的合理性，教材选择的恰当性，还是评论看法的确切性，都有待于通过使用和实践来检验。感谢使用本系列教材的广大教师和学生的支持。期望广大读者提出意见和建议。

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Basic Engineering Circuit Analysis, 7th Edition

影印版前言

由美国 J. David Irwin 编著的这本《工程电路分析基础》（第 7 版）是为学习工科电类的各专业，如电气、计算机等专业的学生编写的电路基础课程的教科书。现在见到的第 7 版于 2002 年由世界著名的出版公司 John Wiley & Son 出版发行。据作者在此书序言中提到，此书从初版发行至今已有二十多年，估计总共有上千位教师用它向数以十万计的学生教授过电路课。可见它已被广泛地采用、受到欢迎，是一本颇著声誉的电路教科书。

此书的内容是电路课程的基础知识，它大致可分为以下几部分：1. 电路的基本概念、定律和定理，电阻电路的分析，节点法和回路法，线性电路的几个定理，运算放大器（第 1 章至第 4 章）；2. 电路的暂态分析，电容、电感元件，一阶、二阶电路中的暂态（第 4 章至第 6 章）；3. 正弦交流电路的稳态分析，相量法，变阻抗，复导纳，含互感的电路，电功率，三相电路（第 7 章至第 10 章）；4. 电路的频率特性，频幅特性与频相特性，谐振电路，滤波器电路（第 11 章）；5. 拉普拉斯变换用于电路分析，零点、极点，伯德图，傅里叶分析技术（第 12 章至第 14 章）；6. 二端口网络，网络参数，网络的互连（第 15 章）；7. 基本的半导体电子电路，二极管、双极型三极管和场效应管的结构和特性，它们在放大器和开关电路中的应用（第 16 章）。由此可见，这本教科书的内容是相当精炼的。事实上，这也与当今国内外许多学校在这门课程内容取舍上的做法大体相同。这一方面是因新技术的发展要求课程内容必须精简；另一方面，从电路课程本身和教学经验来考察，这些内容——除了最末一章，较常见的安排是将它放在电子电路的课程中讲授——确实是电路基础课程最必要的内容。

此书作者在序言中称，编写此书旨在为学生提供一个能透彻地理解电路分析的环境，使他们能尽可能迅速地理解和运用此课程的基本知识。作者和参与完成此书的合作者，为此作出了大量精心细致的工作。现在出版的这本书，既有此前各版的成功之作的积累，也有不少更新与充实。概略地讲，它有下面的一些特点。

此书内容的讲述，深入浅出，简要易学。它注重阐明电路课程中的基本概念，密切联系实际。推导证明，力求简洁。书中除有大量例题外，还辅以多种形式的对电路问题的分析讨论，有助于学生迅速掌握课程的基本内容。

此书在讲述电路的分析方法的同时，结合电工新技术，尤其是电子技术，介绍了一些新知识，如运算放大器的电路、有源滤波器、电子电路元件的特性及应用等。书中还有着许多结合电路实际问题的分析和讨论。这些内容的引入对增进学生对电路的工程实际的认识，理解电路知识的实际应用，乃至开阔思路，都将是有帮助的。

此书每章都有为数甚多不同难度的习题。书中对计算机辅助电路分析的软件 PSPICE 和 MATLAB 的使用作了介绍，并有许多用它们进行电路分析的例题和习题。

配合此书的使用，出版者还设立了多个电路教学辅助网站，可为学生和教师提供许多便利。

此书可供工科电类各专业学生用作电路基础课程的教科书，也可供其他专业学生学习电路课程之用。对于有关的高校教师和科技人员，此书也很有参考价值。

江缉光教授
清华大学电机系
2005 年 10 月

Preface

The Circuit Analysis Course in the Engineering Curriculum

Circuit analysis is not only fundamental to the areas of electrical and computer engineering—the concepts studied also have tentacles that extend to areas far beyond the boundaries of these topics. Today, this subject may get less time in the curriculum than in the past because of constraints that range from attempts to reduce the total number of hours required for graduation to the size or even growth of the university's core requirement. Therefore, a viable book on this topic must be designed to enhance the learning process on every possible front; that is, it must (1) be easily readable, (2) contain numerous learning aids so that the material can be quickly grasped, and (3) provide ample opportunity for readers to become proficient by testing their understanding. Thus, success is dependent not only on learning the material, but also on learning it quickly. I have designed this book to match those needs.

How This Text Meets the Needs of Instructor and Student

Seven editions of *Basic Engineering Circuit Analysis* have provided readers with a thorough understanding of the fundamental concepts of circuit analysis and their applications to real-world problems. Over the almost 20-year life cycle of this text, instructors and students alike have found the book's most helpful features to be:

1. the clear and concise explanations
2. a variety of effective learning aids
3. numerous problems with varying degrees of difficulty
4. a variety of real-world examples that demonstrate the usefulness of the material under discussion.

Like the previous editions, the seventh edition is designed as a core text for students majoring in electrical and computer engineering, as well as a basic introduction to electric circuits for students in other engineering disciplines. The goal is to provide an effective and efficient environment for students to obtain a thorough understanding of the analysis of electric circuits and an introduction to their design. The material is presented at a level suitable for students who are taking or have completed the introductory courses in college calculus and physics. I have taken great care to provide complete and clear discussions, as well as an abundant supply of new learning aids.

ACCURACY The text and problems/solutions have been thoroughly checked for clarity and accuracy not only by the author, but also by more than a dozen academics and one honor student. This group consists of 11 reviewers who are well-known professors of ECE, and they are:

Robert Krueger, University of Wisconsin
Ashok Goel, Michigan Technological University

Clifford Pollock, Cornell University
Peyton Peebles, University of Florida
Marty Kaliski, Cal Poly, San Luis Obispo
Darryl Morrell, Arizona State University
Peddapullaiah Sannuti, Rutgers University
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Jorge Aravena, LSU
James Rowland, University of Kansas
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In addition, the following individuals served as accuracy checkers for every aspect of the text:

Professor Scott Smith, Boise State University
Professor Val Tareski, North Dakota State University
Mr. Jung Young Lee, UC Berkeley

FLEXIBILITY While the organization and presentation of the material have been designed to enable students to understand and apply the fundamentals as quickly as possible, the organization also provides instructors maximum flexibility to use the text in a variety of different course settings and learning styles. Some sections or chapters can be skipped completely and still provide a coherent presentation in a natural progression from start to finish. For example, those instructors who do not wish to cover the CAD tools, that is, PSPICE, MATLAB, and Microsoft EXCEL, can skip them with no loss of continuity. On the other hand, one could make computer-generated solutions a major focus of the course. In addition, the design material permits instructors to introduce this important topic early in the curriculum.

Pedagogical Structure Designed to Reinforce Learning

Students don't all learn in the same way. Some are visual learners, while others are more kinesthetic. A "learning styles survey" appears after the preface to help each student determine his or her particular learning style and gives guidance on how to tailor his or her study habits. Pedagogical features are included to fit different learning styles.

- ***Learning Goals***, listed at the beginning of each chapter, provide an overview of the topics within the chapter and the skills and knowledge students should achieve.
- ***Learning Hints*** that appear on many pages of the text help shorten the learning curve. These comments in the margin provide guidance for understanding different facets of the presentation and problems of all types. Coupled with myriad examples, Learning Hints provide readers with a companion tutor. Additionally, they aid the instructor and the student by conveying some of the subtleties that are typically implicit in lecture or in traditional presentation.
- ***Learning by Example*** sections, more often than any other component, provide students with the means for acquiring and evaluating new knowledge. The numerous worked-out examples in the text are the hallmark feature.
- An expanded number of real-world examples, labeled ***Learning by Application***, appear in many sections of the text, and at the end of every applicable chapter, answer the question "Why do we study circuit theory?" Applications frequently deal with design issues ranging from very simple matters, such as finding the value of some specific component, to modeling the collapse of the Tacoma Narrows Bridge.
- ***Learning by Doing*** and ***Learning Extensions*** are assessment tools coordinated within the text. The Learning by Doing exercises are quick, simple reinforcements of the principles and provide a check of the reader's understanding of the material. Learning Extensions

provide practice for the reader in applying the basic concepts, as well as guidance in understanding the techniques needed to solve the end-of-chapter problems.

- ***Problem-Solving Strategies*** are placed to assist the student in selecting the proper solution technique, or combination of techniques applicable in a particular situation. This assistance not only helps the student understand the subtle differences among various techniques in their application to a particular problem, but also helps eliminate the psychological barrier that sometimes exists in determining a suitable method of attack.
- ***Computer-aided Design (CAD) Tools*** allow students, like all modern engineers, to apply the power of the computer to solve a variety of problems. Special icons are employed within the book to indicate sections where the CAD tools are used. The very latest version of PSPICE by Cadence is used, and this version coupled with the use of both MATLAB and Microsoft EXCEL are integrated within the text and coordinated with the Student Study Guide (discussed later) where Electronics Workbench is also introduced.
- ***Learning by Design*** sections appear at the end of each applicable chapter. This feature provides the reader with an understanding of how to apply what they have learned to the design of circuits. The use of engineering design in a curriculum is a major component of the ABET criteria. The inclusion of this material permits its introduction to the student at an early stage in the curriculum.
- ***Learning Check*** includes both the Summary and Problems, and appears at the end of every chapter. The important topics are reviewed concisely in the Summary as a quick reminder for readers. The problems are segmented by chapter subdivision and graduated in difficulty to permit users to test their understanding of the material and hone their skills in solving different types of problems. *The problem sets also include some problems specifically designed to mimic those that appear on the Fundamentals of Engineering (FE) Exam taken by students in preparation for becoming a Registered Professional Engineer.*

New to This Edition

This edition generally follows the presentation outlined in previous editions. However, I have made some important changes that are designed to meet the current needs of the course and that respond to the experience and comments of colleagues who have taught from the book. As is my custom, the problem sets are new, the presentation has been streamlined to include important new material, and a number of new and exciting real-world applications are presented throughout. Other specific improvements are outlined on a chapter-by-chapter basis as follows:

Chapter 2—Standard resistor values are presented, and their tolerances and power ratings are discussed using examples. The delta/wye and wye/delta transformations have also been inserted here.

Chapter 3—MATLAB is introduced here as a CAD tool for solving a set of linearly independent simultaneous equations for both nodal and loop analysis. The presentation of op-amps is updated to reflect the use of modern components.

Chapter 4—Microsoft EXCEL is introduced and the new version of PSPICE by Cadence is introduced and employed in the solution of dc circuits.

Chapter 5—Standard values for capacitors and inductors are given, and their tolerances and specific component ratings are discussed using examples.

Chapter 6—Both first- and second-order transient circuits are combined in this chapter. MATLAB plotting routines are used to obtain transient response plots, and PSPICE is used in the solution of transient problems.

Chapter 7—Both MATLAB and PSPICE are employed to obtain solutions to ac steady-state circuit analysis problems. PSPICE can also be used to sweep the frequency to obtain plots of magnitude and phase.

Chapter 8—The Magnetically Coupled Networks chapter has been moved forward to this location.

Chapter 11—Variable frequency network performance has moved to this chapter, and MATLAB is employed to obtain the magnitude and phase plots from a transfer function. The Operational Transconductance Amplifier (OTA) is also introduced as a viable component for wireless applications, which include high-frequency active filters and low-voltage circuitry.

Chapter 12—MATLAB is used to obtain the inverse Laplace transform and perform a convolution.

Chapter 14—Fourier analysis techniques have been moved to this location. PSPICE is used to obtain the Fourier series components of a waveform.

Chapter 15—Two-Port Networks have been moved from an appendix to a full chapter.

Chapter 16—This new chapter provides an introduction to semiconductor electronics. Diodes and transistors and some of their applications are examined.

Companion Web Site

Among other items, this site contains *Answers to Selected Problems.*

Supplements

The ***Student Study Guide*** for the seventh edition contains additional detailed examples that track the chapter presentation to aid and check the student's understanding of the problem-solving process. Many of these examples involve computer simulations with PSPICE, MATLAB, Microsoft EXCEL, and Electronics Workbench. A CD bound into the study guide includes circuit simulations and five easy-to-use video segments for demonstrating PSPICE solutions.

EGrade Anonymous Quizzing is also available to students using this text. Students are encouraged to visit our web site at *www.wiley.com/college/circuitsextra* and register to begin taking practice quizzes on eGrade to increase their circuits problem-solving skills. EGrade questions are organized by topic and are automatically scored to provide immediate feedback, so the student can either drill specifically in problem areas (focusing on topics he or she needs more work in) or just do general practice drills to prepare for a test.

Problem-Solving Companion is available for download from the text web site. This *Companion* contains over 70 additional problems with extremely detailed worked-out solutions to walk you through the problem-solving process. It also includes techniques for solving linearly independent simultaneous equations. Visit the web site at *www.wiley.com/college/elec/irwin407402* for an example from this resource.

Circuits Extra—Check out the latest offerings for users of Wiley circuits texts.

EGrade On-line Assessment is also available for this text. EGrade is a tool that allows instructors to automate the process of assigning, delivering, grading, and routing all kinds of homework, quizzes, and tests, while providing students with immediate scoring and feedback on their work. Electric circuits test banks in eGrade format are available for instructors who would like to include a web component in their course in the form of on-line homework and quizzing. Questions are arranged by topic and are in a variety of formats, including fill-in-the-blank, multiple choice, true/false, and more. For more information, and to see a demo of eGrade, visit *www.wiley.com/college/egrade*.

The ***Solutions Manual***, containing solutions to all learning extensions and end-of-chapter problems, and *PowerPoint Slides* for this text are available only to instructors who have adopted the

text for classroom use. The solutions manual and PowerPoint slides are available on the web site at *www.wiley.com/college/elec/irwin407402*, under the *Instructor's Companion Site*. You must first register for a password on-line and supply your course information for confirmation before you will receive access to these resources.

Circuit Works is a simulator based on a set library of 100 circuits, with adjustable parameters and 35 parameterized signal generators. This tool helps you to succeed by learning the principles and relationships that underlie basic first- and second-order circuits having resistors, capacitors, inductors, op-amps, dependent and independent sources, and tranformers.
Circuit Works is free to purchasers of this text. To download *Circuit Works* for free, simply go to the web site at *http://www.wiley.com/college/circuitworks* and register with the unique password included on the inside cover of this text.

Acknowledgements

Over the approximate 20-year period that this text has been employed, it is estimated that more than one thousand instructors have used my book to teach circuit analysis to hundreds of thousands of students. I am most grateful for the confidence that has been demonstrated in the educational soundness of the text. In addition, I have received numerous evaluations and suggestions from professors and their students over the years, and their feedback has helped me continuously improve the presentation. For this seventh edition, I would especially like to express my appreciation to a number of individuals and groups. I owe Bill Dillard at Auburn University a special debt of gratitude for the numerous contributions that he made to the development of new material in the text, as well as some of the supporting material. I am also most appreciative of the suggestions for improvement that were made by Professor John Choma of the University of Southern California and Professor Mark Nelms of Auburn University.

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While this is the seventh edition of this book, it is the very first edition for John Wiley & Sons, Inc. The preparation of this book and the numerous ancillary documents that support it have been handled with both enthusiasm and great care. The combined wisdom and leadership of Bill Zobrist, my Executive Editor, has resulted in a tremendous team effort that has addressed every aspect of the presentation. This team included the following individuals:

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Seth Wolpert, University of Maine

Finally, I wish to express my deep appreciation to my wife, Edie, who has been most supportive of my efforts with this book.

J. David Irwin

Learning Styles Survey

How Do I Learn Best?

This questionnaire aims to find out something about your preferences for the way you work with information. You will have a preferred learning style, and one part of that learning style is your preference for the intake and the output of ideas and information.

Circle the letter of the answer that best explains your preference. Circle more than one if a single answer does not match your perception. Leave blank any question that does not apply.

1. You are about to give directions to a person who is standing with you. She is staying in a hotel in town and wants to visit your house later. She has a rental car. Would you
   - **a.** draw a map on paper?
   - **b.** tell her the directions?
   - **c.** write down the directions (without a map)?
   - **d.** pick her up at the hotel in your car?

2. You are not sure whether a word should be spelled "dependent" or "dependant." Do you
   - **c.** look it up in the dictionary?
   - **a.** see the word in your mind and choose by the way it looks?
   - **b.** sound it out in your mind?
   - **d.** write both versions down on paper and choose one?

3. You have just received a copy of your itinerary for a world trip. This is of interest to a friend. Would you
   - **b.** call her immediately and tell her about it?
   - **c.** send her a copy of the printed itinerary?
   - **a.** show her on a map of the world?
   - **d.** share what you plan to do at each place you visit?

4. You are going to cook something as a special treat for your family. Do you
   - **d.** cook something familiar without the need for instructions?
   - **a.** thumb through the cookbook looking for ideas from the pictures?
   - **c.** refer to a specific cookbook where there is a good recipe?

5. A group of tourists has been assigned to you to find out about wildlife reserves or parks. Would you
   - **d.** drive them to a wildlife reserve or park?
   - **a.** show them slides and photographs?
   - **c.** give them pamphlets or a book on wildlife reserves or parks?
   - **b.** give them a talk on wildlife reserves or parks?

6. You are about to purchase a new CD player. Other than price, what would most influence your decision?
   - **b.** The salesperson telling you what you want to know.
   - **c.** Reading the details about it.
   - **d.** Playing with the controls and listening to it.
   - **a.** Its fashionable and upscale appearance.

7. Recall a time in your life when you learned how to do something like playing a new board game. Try to avoid choosing a very physical skill, e.g., riding a bike. How did you learn best? By
   - **a.** visual clues—pictures, diagrams, charts?
   - **c.** written instructions?
   - **b.** listening to somebody explaining it?
   - **d.** doing it or trying it?

8. You have an eye problem. Would you prefer that the doctor
   - **b.** tell you what is wrong?
   - **a.** show you a diagram of what is wrong?
   - **d.** use a model to show what is wrong?

9. You are about to learn to use a new program on a computer. Would you
   - **d.** sit down at the keyboard and begin to experiment with the program's features?
   - **c.** read the manual that comes with the program?
   - **b.** call a friend and ask questions about it?

10. You are staying in a hotel and have a rental car. You would like to visit friends whose address/location you do not know. Would you like them to
    - **a.** draw you a map on paper?
    - **b.** tell you the directions?
    - **c.** write down the directions (without a map)?
    - **d.** pick you up at the hotel in their car?

11. Apart from price, what would most influence your decision to buy a particular book?
    - **d.** You have used a copy before.
    - **b.** A friend talking about it.
    - **c.** Quickly reading parts of it.
    - **a.** The appealing way it looks.

12. A new movie has arrived in town. What would most influence your decision to go (or not go)?
    - **b.** You heard a radio review about it.
    - **c.** You read a review about it.
    - **a.** You saw a preview of it.

13. Do you prefer a lecturer or teacher who likes to use
    - **c.** a textbook, handouts, readings?
    - **a.** flow diagrams, charts, graphs?
    - **d.** field trips, labs, practical sessions?
    - **b.** discussion, guest speakers?

Count Your Choices:	**a.** ❑	**b.** ❑	**c.** ❑	**d.** ❑
	V	**A**	**R**	**K**

Now match the letter or letters you have recorded most to the same letter or letters in the learning styles chart. You may have more than one learning style preference—many people do. Next to each letter in the chart are suggestions that will refer you to different learning aids throughout this text.

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Learning Styles Chart

Visual

INTAKE: TO TAKE IN THE INFORMATION	TO MAKE A STUDY PACKAGE	TEXT FEATURES THAT MAY HELP YOU THE MOST	OUTPUT: TO DO WELL ON EXAMS
• Pay close attention to charts, drawings, and handouts your instructor uses. • Underline. • Use different colors. • Use symbols, flow charts, graphs, different arrangements on the page, white space.	Convert your lecture notes into "page pictures." To do this: • Use the "Intake" strategies. • Reconstruct images in different ways. • Redraw pages from memory. • Replace words with symbols and initials. • Look at your pages.	**Learning Goals** **Charts of real-world values** **Endpaper charts** **Photos of circuit components** **Learning by Example** **Learning by Application** **Problem-Solving Strategies** **Learning by Design** **Learning Check (Problems)** **Tools for Learning (MATLAB and PSPICE)** ***Answers to Selected Problems*** ***Problem-Solving Companion*** ***Student Study Guide***	• Recall your "page pictures." • Draw diagrams where appropriate. • Practice turning your visuals back into words.

Aural

INTAKE: TO TAKE IN THE INFORMATION	TO MAKE A STUDY PACKAGE	TEXT FEATURES THAT MAY HELP YOU THE MOST	OUTPUT: TO DO WELL ON EXAMS
• Attend lectures and tutorials. • Discuss topics with students and instructors. • Explain new ideas to other people. • Use a tape recorder. • Leave spaces in your lecture notes for later recall. • Describe overheads, pictures, and visuals to somebody who was not in class.	You may take poor notes because you prefer to listen. Therefore: • Expand your notes by talking with others and with information from your textbook. • Tape record summarized notes and listen. • Read summarized notes out loud. • Explain your notes to another "aural" person.	**Learning Goals** **Learning Hints** **Learning by Example** **Problem-Solving Strategies** **Learning by Application** **Learning Check (Summary & Problems)**	• Talk with the instructor. • Spend time in quiet places recalling the ideas. • Practice writing answers to old exam questions. • Say your answers out loud.

Reading/Writing

INTAKE: TO TAKE IN THE INFORMATION	TO MAKE A STUDY PACKAGE	TEXT FEATURES THAT MAY HELP YOU THE MOST	OUTPUT: TO DO WELL ON EXAMS
• Use lists and headings. • Use dictionaries, glossaries, and definitions. • Read handouts, textbooks, and supplementary library readings. • Use lecture notes.	• Write out words again and again. • Reread notes silently. • Rewrite ideas and principles into other words. • Turn charts, diagrams, and other illustrations into statements.	**Learning Goals** **Learning Hints** **Endpaper charts** **Learning by Example** **Learning by Application** **Problem-Solving Strategies** **Learning by Design** **Learning Check (Summary & Problems)** **Tools for Learning (MATLAB and PSPICE)** ***Answers to Selected Problems*** ***Problem-Solving Companion*** ***Student Study Guide***	• Write exam answers. • Practice with multiple-choice questions. • Write paragraphs, beginnings and endings. • Write your lists in outline form. • Arrange your words into hierarchies and points.

Kinesthetic

INTAKE: TO TAKE IN THE INFORMATION	TO MAKE A STUDY PACKAGE	TEXT FEATURES THAT MAY HELP YOU THE MOST	OUTPUT: TO DO WELL ON EXAMS
• Use all your senses. • Go to labs, take field trips. • Listen to real-life examples. • Pay attention to applications. • Use hands-on approaches. • Use trial-and-error methods.	You may take poor notes because topics do not seem concrete or relevant. Therefore: • Put examples in your summaries. • Use case studies and applications to help with principles and abstract concepts. • Talk about your notes with another "kinesthetic" person. • Use pictures and photographs that illustrate an idea.	**Learning by Doing** **Learning Hints** **Learning by Example** **Learning Applications** **Extending Your Learning** **Learning by Design** **Learning Check (Problems)** **Tools for Learning (MATLAB and PSPICE)** ***Answers to Selected Problems*** ***Problem-Solving Companion*** ***Student Study Guide***	• Write practice answers. • Role-play the exam situation.

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