

DELMAR'S

Standard Textbook of Electricity

FIFTH EDITION



Stephen L. Herman



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**Standard
Textbook of
Electricity**

FIFTH EDITION

Stephen L. Herman



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To my wife, Debbie, God's greatest gift to me.

Preface



Intended Use

Delmar's Standard Textbook of Electricity, 5th edition, is intended for students in electrical trade programs at high schools and community colleges, as well as those in industry training. It assumes that the reader has had no prior knowledge of electricity but also provides enough comprehensive coverage to be used as a reference tool for experienced electricians.

Subject & Approach

The content itself is presented as a blend of the practical and theoretical. It not only explains the different concepts relating to electrical theory but also provides many practical examples of how to do many of the common tasks the industrial electrician must perform. An extensive art program containing full color photographs and line drawings, as well as the inclusion of practical exercises for the student, also serve to further clarify theoretical concepts.

Design of Text

The subject matter has been divided into 34 separate units—each designed to “stand alone.” The “stand alone” concept permits the information to be presented in almost any sequence the instructor desires, as teaching techniques vary from one instructor to another. The information is also presented in this manner to allow students and instructors quick reference on a particular subject.

Math Level

The math level has been kept to basic algebra and trigonometry, and Appendix B contains a section of electrical formulas—all divided into groups that are related to a particular application. Unit 15 of the text provides an introduction to basic trigonometry and vectors for those students weak in the subject.

A Note about Calculations

Delmar's Standard Textbook of Electricity, 5th edition, like all other scientific texts, contains numerous mathematical equations and calculations. Students often become concerned if their

answers to problems are not exactly the same as the solutions given in the text. The primary reason for a discrepancy is the rounding off of values. Different scientific calculators carry out numbers to different places, depending on the manufacturer and model. Some calculators carry numbers to 8 places, some to 10 places, and some to 12 places. There may also be times when numbers that are reentered into the calculator are carried to only 2 or 3 decimal places of accuracy. For example, the numbers shown below will be multiplied with a calculator that carries numbers out to 8 places of accuracy:

$$3.21 \times 34.6 \times 4.32 \times 0.021 \times 3.098 \times 0.467$$

The answer is 14.577480.

The same problem will again be multiplied, but this time each answer will be reentered before it is multiplied by the next number. Each time the answer is reentered, it will be rounded off to 3 places after the decimal. If the fourth number after the decimal is 5 or greater, the third decimal place will be rounded up. If the fourth number is less than 5, it will be rounded down. The answer is 14.577405.

The same set of numbers will again be multiplied, but this time each answer will be reentered after rounding off the number to one place after the decimal. The answer is 14.617100.

Notice that all three answers are different, but all three are essentially correct. The most accurate answer is 14.577480, and the least accurate answer is 14.617100. Although these answers may look substantially different, they are within approximately 1% of each other.

Another consideration is problems that contain multiple steps. The more steps it takes to solve a problem, the more chance there is for inaccuracy. In most instances in this text, the answers were left in the display of the calculator, which permits the greatest degree of accuracy. When numbers had to be reentered, they were taken to 3 places of accuracy. When you work a problem in this text and your answer is different, consider the degree of difference before concluding that your answer is incorrect.

New to this Edition



The fifth edition of *Delmar's Standard Textbook of Electricity* continues to remain true to the comprehensive nature and visually appealing style that are its trademark features but will now offer more emphasis on the practical approach to electrical theory. New to this edition:

- ***Explanation of the American Wire Gauge measurement used throughout industry***

- **Extended coverage of the effects of temperature on conductor resistance**
- **Coverage of fuel cells**
- **The addition of constant-current transformers**
- **Coverage of parallel transformer connections**
- **Energy saving “Green Tips” where applicable**
- **New Introduction**
 “Electrical Occupations” contains information about electrical personnel, building codes, and solar and wind energy.

Features of The Text

- **“Safety Overview”**
 At the beginning of Section I, Safety Overview provides information on general safety rules, personal protective equipment, potential job hazards, lock-out/tag-out procedures, GFCI, Grounding—and more! Students are acquainted with the all important safety concerns applicable to working in a lab and on the work site.
- **“Cautions”**
 Author highlights text where students should be aware of potential risks in working with various types of electrical equipment.

	<p>Caution: The ammeter, unlike the voltmeter, is a very low-impedance device. The ammeter is used to measure current and must be connected in series with the load to permit the load to limit the current flow (Figure 10–13). ■</p>	
---	--	--

- **Math Presentation**
 Section on vectors in Unit 17 is presented earlier in the text in Unit 15, *Basic Trigonometry*, providing a foundation for students as they work through math equations.

EXAMPLE 15-3

Using the same triangle (Figure 15-7), determine the number of degrees in angle Y.

Solution

In this example, the lengths of the hypotenuse and the adjacent side are known. The cosine function can be used to find the angle:

$$\text{cosine } \angle Y = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\text{cosine } \angle Y = \frac{9}{14}$$

$$\text{cosine } \angle Y = 0.643$$

To find what angle corresponds to the cosine of 0.643, use the trigonometric tables in Appendices A and B or the COS function of a scientific calculator:

$$\text{COS}^{-1} \text{ or ARC COS } 0.643 = 50^\circ$$

15-4 Formulas

Some formulas that can be used to find the angles and lengths of different sides follow:

$$\sin \angle \theta = \frac{O}{H}$$

$$\cos \angle \theta = \frac{A}{H}$$

$$\tan \angle \theta = \frac{O}{A}$$

$$\text{Adj.} = \cos \angle \theta \times \text{Hyp.}$$

$$\text{Adj.} = \frac{O}{\tan \angle \theta}$$

$$\text{Opp.} = \sin \angle \theta \times \text{Hyp.}$$

$$\text{Opp.} = \text{Adj.} \times \tan \angle \theta$$

$$\text{Hyp.} = \frac{O}{\sin \angle \theta}$$

$$\text{Hyp.} = \frac{A}{\cos \angle \theta}$$

15-5 Practical Application

Although the purpose of this unit is to provide preparation for the study of AC circuits, basic trigonometry can provide answers to other problems that may be encountered on the job. Assume that it is necessary to know the height of a

• **“Why You Need to Know”**

Boxed articles at the beginning of each unit explain to students the importance of learning the material presented in each unit, and how it may apply to actual job situations.

Unit 34
Single-Phase Motors

OUTLINE

- 34-1 Single-Phase Motors
- 34-2 Split-Phase Motors
- 34-3 Resistance-Start Induction-Run Motors
- 34-4 Capacitor-Start Induction-Run Motors
- 34-5 Dual-Voltage Split-Phase Motors
- 34-6 Determining the Direction of Rotation for Split-Phase Motors
- 34-7 Capacitor-Start Capacitor-Run Motors
- 34-8 Shaded-Pole Induction Motors
- 34-9 Multispeed Motors
- 34-10 Repulsion-Type Motors
- 34-11 Construction of Repulsion Motors
- 34-12 Repulsion-Start Induction-Run Motors
- 34-13 Repulsion-Induction Motors
- 34-14 Single-Phase Synchronous Motors
- 34-15 Stepping Motors
- 34-16 Universal Motors

KEY TERMS

Centrifugal switch	Run winding
Compensating winding	Shaded-pole induction motor
Conductive	Shading coil

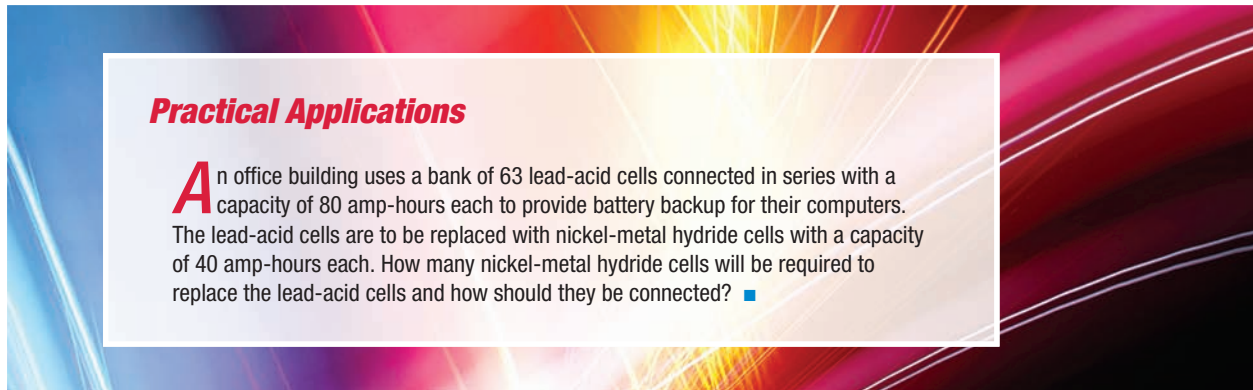
Why You Need to Know

Single-phase motors are used almost exclusively in residential applications and to operate loads that require fractional horsepower motors in industrial and commercial locations. Many of these motors you will recognize from everyday life and may have wondered how they work. Unlike three-phase motors, there are many different types of single-phase motors and they do not all operate on the same principle. There are some that operate on the principle of a rotating magnetic field, but others do not. Some single-phase motors are designed to operate at more than one speed. This unit

- presents several different types of single-phase motors and explains how they operate.
- explains how to determine the appropriate motor to be used under a given situation by evaluating the operating principles of each.

- **“Practical Applications”**

Word problems step the students through potential situations on the job and encourage them to develop critical thinking skills.



Practical Applications

An office building uses a bank of 63 lead-acid cells connected in series with a capacity of 80 amp-hours each to provide battery backup for their computers. The lead-acid cells are to be replaced with nickel-metal hydride cells with a capacity of 40 amp-hours each. How many nickel-metal hydride cells will be required to replace the lead-acid cells and how should they be connected? ■

- **DVD Correlation**

Units are highlighted where material can be viewed on the accompanying DVD series, providing another source of learning for the student:

DC Electrical Theory, AC Electrical Theory, Single-Phase Transformers & Electrical Machines, Three-Phase Circuits & Electrical Machines

- **Text Design**

A fresh design creates a text that makes it even easier to navigate through content, serving to facilitate learning for students.

- **New, Up-to-Date Art**

Approximately 32 new four-color photos and line illustrations combined bring text up to date, keeping students aware of the latest technology in the industry.

- **Dedication to Technical Accuracy and Consistency**

Text was thoroughly reviewed for technical accuracy and consistency, ensuring existing errors were corrected, enabling students to readily grasp more difficult concepts.

Supplement Package

- **Lab-Volt Manual** provides experiments for students to test and troubleshoot key concepts presented in the text, using Lab-volt equipment. (Order #: 1-1115-3916-2).

Also available: The Complete Laboratory Manual for Electricity, by Steve Herman. This manual is designed to be conducted with common lab equipment. (Order #: 1-4283-2430-5).

- **Instructor Resource (CD-ROM for Instructors)**

(Order #: 1-1115-3916-2).

Instructor Guide contains answers to all review questions and practical applications contained within the text, as well as practice exams.

- *PowerPoint* presentations provide a thorough review of all major concepts presented in each unit, featuring four-color photos and line illustrations from the text. The fifth edition contains numerous PowerPoint presentations not available before.
- *Computerized Testbank* offered in *ExamView 4.0* contains approximately 700 questions for instructors to test student knowledge as they progress through the text. Allows instructors to edit the exams and add their own questions.
- *Image Library* consists of all the images from the text in electronic format, allowing instructors to create their own classroom presentations.
- *Video Clips* drawn from each video provide key lessons from the series.
- *Instructors Guide & Solutions to Lab-Volt Manual* is in Word format.

To access additional course materials including CourseMate, please visit www.cengagebrain.com. At the CengageBrain.com home page, search for the ISBN of your title (from the back cover of your book) using the search box at the top of the page. This will take you to the product page where these resources can be found.

- **A DVD Set** brings important concepts to life through easy-to-understand explanations and examples, professional graphics and animations, and a necessary emphasis on safety. Videos run approximately 20 minutes. The DVDs are interactive and provide test questions and remediation.

DC Electrical Theory DVD (4 videos) includes Basic Electricity, Series & Parallel Circuits, Combination Circuits, and Small Sources of Electricity.

AC Electrical Theory DVD (5 videos) includes Alternating Current, Inductance, Capacitors, Capacitors in AC Circuits, and Series Circuits.

Single-Phase Transformers & Electrical Machines DVD (4 videos) includes Single-Phase Transformers; DC Machines; Single-Phase Motors, Part I; Single-Phase Motors, Part II.

Three-Phase Circuits & Electrical Machines DVD (4 videos) includes Three-Phase Circuits; Three-Phase Transformers; Three-Phase Motors, Part I; Three-Phase Motors, Part II.

- **Blackboard supplement** features include chapter objectives, practice tests, glossary, and links to relevant websites. (Order #: 1-1115-3918-9).

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