

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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Library of Congress Control Number: 2010932363

ISBN-13: 978-1-1115-3915-3

ISBN-10: 1-1115-3915-4

Delmar5 Maxwell Drive
Clifton Park, NY 12065-2919
USA

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Printed in Canada**1 2 3 4 5 X X 10 09 08**

Contents

Dedication	xvi
Preface	xvii
Introduction: Electrical Occupations	xxv

SECTION I

Safety, Basic Electricity, and Ohm's Law **2**

SAFETY OVERVIEW

S-1	General Safety Rules	4
S-2	Effects of Electric Current on the Body	6
S-3	On the Job	7
S-4	Protective Clothing	12
S-5	Ladders and Scaffolds	16
S-6	Fires	19
S-7	Ground-Fault Circuit Interrupters	20
S-8	Arc-Fault Circuit Interrupters (AFCIs)	22
S-9	Grounding	28

UNIT 1

Atomic Structure **34**

1-1	Early History of Electricity	35
1-2	Atoms	37
1-3	The Law of Charges	41
1-4	Structure of the Atom	42
1-5	Electron Orbits	44
1-6	Valence Electrons	46
1-7	Electron Flow	47
1-8	Insulators	52
1-9	Semiconductors	52
1-10	Molecules	53
1-11	Methods of Producing Electricity	54
1-12	Electrical Effects	56

UNIT 2

Electrical Quantities and Ohm's Law **59**

2-1	The Coulomb	60
2-2	The Ampere	61
2-3	The Electron Flow Theory	62

2-4	The Conventional Current Flow Theory	62
2-5	Speed of Current	64
2-6	Basic Electric Circuits	67
2-7	The Volt	69
2-8	The Ohm	70
2-9	The Watt	72
2-10	Other Measures of Power	74
2-11	Ohm's Law	76
2-12	Metric Prefixes	82

UNIT 3

Static Electricity **88**

3-1	Static Electricity	89
3-2	Charging an Object	91
3-3	The Electroscope	91
3-4	Static Electricity in Nature	94
3-5	Nuisance Static Charges	97
3-6	Useful Static Charges	98

UNIT 4

Magnetism **103**

4-1	The Earth Is a Magnet	104
4-2	Permanent Magnets	106
4-3	The Electron Theory of Magnetism	106
4-4	Magnetic Materials	108
4-5	Magnetic Lines of Force	109
4-6	Electromagnetics	110
4-7	Magnetic Measurement	113
4-8	Magnetic Polarity	115
4-9	Demagnetizing	116
4-10	Magnetic Devices	117

UNIT 5

Resistors **120**

5-1	Uses of Resistors	121
5-2	Fixed Resistors	123
5-3	Color Code	126
5-4	Standard Resistance Values of Fixed Resistors	132

5-5	Power Ratings	134
5-6	Variable Resistors	135
5-7	Schematic Symbols	138

SECTION II

Basic Electric Circuits 142

UNIT 6

Series Circuits 143

6-1	Series Circuits	144
6-2	Voltage Drops in a Series Circuit	145
6-3	Resistance in a Series Circuit	147
6-4	Calculating Series Circuit Values	147
6-5	Solving Circuits	149
6-6	Voltage Dividers	162
6-7	The General Voltage Divider Formula	164
6-8	Voltage Polarity	165
6-9	Using Ground as a Reference	166

UNIT 7

Parallel Circuits 172

7-1	Parallel Circuit Values	173
7-2	Parallel Resistance Formulas	176

UNIT 8

Combination Circuits 198

8-1	Combination Circuits	199
8-2	Solving Combination Circuits	200
8-3	Simplifying the Circuit	201

UNIT 9

Kirchhoff's Laws, Thevenin's, Norton's, and Superposition Theorems 226

9-1	Kirchhoff's Laws	227
9-2	Thevenin's Theorem	234

9-3	Norton's Theorem	238
9-4	The Superposition Theorem	242

SECTION III

Meters and Wire Sizes **256**

UNIT 10

Measuring Instruments **257**

10-1	Analog Meters	258
10-2	The Voltmeter	260
10-3	Multirange Voltmeters	262
10-4	Reading a Meter	264
10-5	The Ammeter	268
10-6	Ammeter Shunts	269
10-7	Multirange Ammeters	272
10-8	The Ayrton Shunt	272
10-9	AC Ammeters	277
10-10	Clamp-On Ammeters	281
10-11	DC-AC Clamp-On Ammeters	284
10-12	The Ohmmeter	287
10-13	Shunt-Type Ohmmeters	289
10-14	Digital Meters	290
10-15	The Low-Impedance Voltage Tester	294
10-16	The Oscilloscope	296
10-17	The Wattmeter	307
10-18	Recording Meters	309
10-19	Bridge Circuits	311

UNIT 11

Using Wire Tables and Determining Conductor Sizes **317**

11-1	The American Wire Gauge (AWG)	318
11-2	Using the <i>NEC</i> Charts	321
11-3	Factors That Determine Ampacity	323
11-4	Correction Factors	325
11-5	Calculating Conductor Sizes and Resistance	332
11-6	Calculating Voltage Drop	343
11-7	Parallel Conductors	345
11-8	Testing Wire Installations	349

SECTION IV**Small Sources of Electricity 356****UNIT 12****Conduction in Liquids and Gases 357**

12-1 The Ionization Process: Magnesium and Chlorine	358
12-2 Other Types of Ions	361
12-3 Electroplating	361
12-4 Electrolysis	363
12-5 Conduction in Gases	363
12-6 Ionization in Nature	368

UNIT 13**Batteries and Other Sources of Electricity 370**

13-1 History of the Battery	371
13-2 Cells	373
13-3 Cell Voltage	374
13-4 Primary Cells	375
13-5 Secondary Cells: Lead-Acid Batteries	384
13-6 Other Secondary Cells	390
13-7 Series and Parallel Battery Connections	393
13-8 Other Small Sources of Electricity	395

UNIT 14**Magnetic Induction 408**

14-1 Electromagnetic Induction	409
14-2 Fleming's Left-Hand Generator Rule	412
14-3 Moving Magnetic Fields	413
14-4 Determining the Amount of Induced Voltage	413
14-5 Lenz's Law	414
14-6 Rise Time of Current in an Inductor	417
14-7 The Exponential Curve	419
14-8 Inductance	421
14-9 R-L Time Constants	423
14-10 Induced Voltage Spikes	424

SECTION V**Basics of Alternating Current 432****UNIT 15****Basic Trigonometry and Vectors 433**

15-1 Right Triangles	434
15-2 The Pythagorean Theorem	435
15-3 Sines, Cosines, and Tangents	437
15-4 Formulas	441
15-5 Practical Application	441

UNIT 16**Alternating Current 454**

16-1 Advantages of AC	455
16-2 AC Waveforms	456
16-3 Sine Wave Values	462
16-4 Resistive Loads	470
16-5 Power in an AC Circuit	471
16-6 Skin Effect in AC Circuits	471

SECTION VI**Alternating Current (AC) Circuits Containing Inductance 478****UNIT 17****Inductance in AC Circuits 479**

17-1 Inductance	480
17-2 Inductive Reactance	483
17-3 Schematic Symbols	487
17-4 Inductors Connected in Series	488
17-5 Inductors Connected in Parallel	489
17-6 Voltage and Current Relationships in an Inductive Circuit	491
17-7 Power in an Inductive Circuit	493
17-8 Reactive Power	494
17-9 Q of an Inductor	495

UNIT 18**Resistive-Inductive Series Circuits 502**

18-1	R-L Series Circuits	503
18-2	Impedance	505
18-3	Total Current	507
18-4	Voltage Drop across the Resistor	508
18-5	Watts	509
18-6	Calculating the Inductance	510
18-7	Voltage Drop across the Inductor	510
18-8	Total Voltage	510
18-9	Calculating the Reactive Power	512
18-10	Calculating the Apparent Power	512
18-11	Power Factor	514
18-12	Angle Theta	516

UNIT 19**Resistive-Inductive Parallel Circuits 531**

19-1	Resistive-Inductive Parallel Circuits	532
19-2	Calculating Circuit Values	533

SECTION VII**AC Circuits Containing Capacitors 552****UNIT 20****Capacitors 553**

20-1	Capacitors	554
20-2	Electrostatic Charge	557
20-3	Dielectric Constant	561
20-4	Capacitor Ratings	562
20-5	Capacitors Connected in Parallel	564
20-6	Capacitors Connected in Series	564
20-7	Capacitive Charge and Discharge Rates	566
20-8	RC Time Constants	567
20-9	Applications for Capacitors	569
20-10	Nonpolarized Capacitors	570
20-11	Polarized Capacitors	573
20-12	Variable Capacitors	576
20-13	Capacitor Markings	577

20–14	Temperature Coefficients	579
20–15	Ceramic Capacitors	579
20–16	Dipped Tantalum Capacitors	580
20–17	Film Capacitors	581
20–18	Testing Capacitors	582

UNIT 21

Capacitance in AC Circuits **589**

21–1	Connecting the Capacitor into an AC Circuit	590
21–2	Capacitive Reactance	592
21–3	Calculating Capacitance	593
21–4	Voltage and Current Relationships in a Pure Capacitive Circuit	594
21–5	Power in a Pure Capacitive Circuit	597
21–6	Quality of a Capacitor	598
21–7	Capacitor Voltage Rating	598
21–8	Effects of Frequency in a Capacitive Circuit	599
21–9	Series Capacitors	601
21–10	Parallel Capacitors	605

UNIT 22

Resistive-Capacitive Series Circuits **613**

22–1	Resistive-Capacitive Series Circuits	614
22–2	Impedance	615
22–3	Total Current	616
22–4	Voltage Drop Across the Resistor	617
22–5	True Power	617
22–6	Capacitance	617
22–7	Voltage Drop Across the Capacitor	618
22–8	Total Voltage	618
22–9	Reactive Power	619
22–10	Apparent Power	619
22–11	Power Factor	620
22–12	Angle Theta	620

UNIT 23

Resistive-Capacitive Parallel Circuits **631**

23–1	Operation of RC Parallel Circuits	632
23–2	Calculating Circuit Values	633

SECTION VIII**AC Circuits Containing
Resistance-Inductance-Capacitance 648****UNIT 24****Resistive-Inductive-Capacitive Series Circuits 649**

24-1 RLC Series Circuits	650
24-2 Series Resonant Circuits	661

UNIT 25**Resistive-Inductive-Capacitive
Parallel Circuits 670**

25-1 RLC Parallel Circuits	671
25-2 Parallel Resonant Circuits	680

UNIT 26**Filters 696**

26-1 Broadband Tuning	698
26-2 Low-Pass Filters	699
26-3 High-Pass Filters	702
26-4 Bandpass Filters	704
26-5 Band-Rejection (Notch) Filters	706
26-6 T Filters	707
26-7 PI-Type Filters	708
26-8 Crossover Networks	708

SECTION IX**Three-Phase Power 714****UNIT 27****Three-Phase Circuits 715**

27-1 Three-Phase Circuits	716
27-2 Wye Connections	718
27-3 Delta Connections	722

27-4	Three-Phase Power	723
27-5	Watts and VARs	724
27-6	Three-Phase Circuit Calculations	725
27-7	Load 3 Calculations	733
27-8	Load 2 Calculations	734
27-9	Load 1 Calculations	735
27-10	Alternator Calculations	735
27-11	Power Factor Correction	736

SECTION X

Transformers

744

UNIT 28

Single-Phase Transformers

745

28-1	Single-Phase Transformers	746
28-2	Isolation Transformers	748
28-3	Autotransformers	774
28-4	Transformer Polarities	777
28-5	Voltage and Current Relationships in a Transformer	782
28-6	Testing the Transformer	784
28-7	Transformer Nameplates	785
28-8	Determining Maximum Current	786
28-9	Transformer Impedance	787

UNIT 29

Three-Phase Transformers

802

29-1	Three-Phase Transformers	803
29-2	Closing a Delta	808
29-3	Three-Phase Transformer Calculations	809
29-4	Open-Delta Connection	815
29-5	Single-Phase Loads	816
29-6	Closed Delta with Center Tap	820
29-7	Closed Delta without Center Tap	821
29-8	Delta-Wye Connection with Neutral	822
29-9	T-Connected Transformers	823
29-10	Scott Connection	826
29-11	Zig-Zag Connection	826
29-12	Harmonics	828

SECTION XI**DC Machines 842****UNIT 30****DC Generators 843**

30-1	What Is a Generator?	844
30-2	Armature Windings	854
30-3	Brushes	856
30-4	Pole Pieces	856
30-5	Field Windings	857
30-6	Series Generators	858
30-7	Shunt Generators	862
30-8	Compound Generators	868
30-9	Compounding	869
30-10	Countertorque	872
30-11	Armature Reaction	873
30-12	Setting the Neutral Plane	876
30-13	Paralleling Generators	877

UNIT 31**DC Motors 883**

31-1	DC Motor Principles	884
31-2	Shunt Motors	887
31-3	Series Motors	890
31-4	Compound Motors	892
31-5	Terminal Identification for DC Motors	894
31-6	Determining the Direction of Rotation of a DC Motor	895
31-7	Speed Control	898
31-8	The Field-Loss Relay	900
31-9	Horsepower	901
31-10	Brushless DC Motors	904
31-11	Converters	907
31-12	Permanent Magnet Motors	908
31-13	The Right-Hand Motor Rule	916

SECTION XII

AC Machines 920

UNIT 32

Three-Phase Alternators 921

32-1	Three-Phase Alternators	922
32-2	The Rotor	926
32-3	The Brushless Exciter	926
32-4	Alternator Cooling	929
32-5	Frequency	930
32-6	Output Voltage	931
32-7	Paralleling Alternators	932
32-8	Sharing the Load	935
32-9	Field-Discharge Protection	935

UNIT 33

Three-Phase Motors 939

33-1	Three-Phase Motors	940
33-2	The Rotating Magnetic Field	941
33-3	Connecting Dual-Voltage Three-Phase Motors	953
33-4	Squirrel-Cage Induction Motors	959
33-5	Wound-Rotor Induction Motors	978
33-6	Synchronous Motors	981
33-7	Selsyn Motors	987

UNIT 34

Single-Phase Motors 995

34-1	Single-Phase Motors	996
34-2	Split-Phase Motors	996
34-3	Resistance-Start Induction-Run Motors	1000
34-4	Capacitor-Start Induction-Run Motors	1008
34-5	Dual-Voltage Split-Phase Motors	1010
34-6	Determining the Direction of Rotation for Split-Phase Motors	1013
34-7	Capacitor-Start Capacitor-Run Motors	1014
34-8	Shaded-Pole Induction Motors	1017
34-9	Multispeed Motors	1021

34–10 Repulsion-Type Motors	1023
34–11 Construction of Repulsion Motors	1023
34–12 Repulsion-Start Induction-Run Motors	1027
34–13 Repulsion-Induction Motors	1029
34–14 Single-Phase Synchronous Motors	1030
34–15 Stepping Motors	1033
34–16 Universal Motors	1041

APPENDIX A

Identifying the Leads of a Three-Phase, Wye-Connected, Dual-Voltage Motor	1050
--	------

APPENDIX B

AC Formulas	1054
-------------	------

APPENDIX C

Greek Alphabet	1066
----------------	------

APPENDIX D

Metals	1067
--------	------

APPENDIX E

Scientific Notation	1069
---------------------	------

APPENDIX F

Answers to Practice Problems	1073
------------------------------	------

Glossary	1091
Index	1104

Tables 310.15(B)(16), 310.15(B)(17), 310.15(B)(18), 310.15(B)(2)(a), and 310.15(B)(3)(a) are reprinted with permission from NFPA 70-2011, the *National Electrical Code*® Copyright © 2010, National Fire Protection Association, Quincy, Massachusetts 02269. This reprinted material is not the complete and official position of the NFPA, on the referenced subject, which is represented only by the standard in its entirety.

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

xvii

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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