Preface

Modern Refrigeration and Air Conditioning is the standard for a new generation of learners. This classic is an excellent blend of theory, skill development, and service techniques to help you learn how to install and service refrigeration and HVAC systems. *Modern Refrigeration and Air Conditioning* delivers comprehensive and authoritative content on the basic and advanced principles of refrigeration and air conditioning, provides excellent instruction and training in the skills and techniques essential for servicing and troubleshooting, and emphasizes career opportunities, workplace skills, and safety.

The content in *Modern Refrigeration and Air Conditioning* is correlated to the curriculum guides and competencies used for HVAC Excellence and ACCE program accreditation. The accreditation curriculum dovetails with entry-level and professional certification exam requirements. Thus, *Modern Refrigeration and Air Conditioning* is a valuable resource as you begin your journey toward entry-level certification, employment, professional certification, and career advancement.

Modern Refrigeration and Air Conditioning has been carefully designed and crafted to make your learning experience effective and efficient. Concepts are explained clearly and simply, with text narrative supported by numerous engaging and attractive illustrations. The format of each chapter helps you quickly master HVACR concepts and topics.

In the coming years, the number of new positions in the HVACR industry combined with open positions due to retirements is expected to be significantly greater than the number of new employees entering the field. This will create a shortage of trained workers and a surplus of employment opportunities. You are entering the HVACR field at an ideal time, and *Modern Refrigeration and Air Conditioning* will be a fantastic resource for you as you build your career!

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About the Authors

Andrew D. Althouse received his engineering degree from the University of Michigan. He was the Assistant Director of the Vocational Education Department at Cass Technical High School in Detroit and later became the Supervisor of Vocational Education for Detroit. As a leader in the field, he and his coauthor Carl Turnquist created one of the first training programs in refrigeration while at Cass Technical High School. Andy, as he was known, created the first technical training course in refrigeration for industry. The instructional materials used in this first course became the foundation for the textbook *Modern Electric and Gas Refrigeration*, which was published in 1933. Mr. Althouse was a member of the American Society of Refrigerating Engineers.

Carl H. Turnquist earned his engineering degree from Wayne State University in Detroit and, along with Mr. Althouse, developed one of the earliest training programs to provide instruction for mechanical refrigeration for the automotive industry and for railroad passenger cars. With industry support, Carl's program flourished as the demand for skilled technicians in this new field expanded. The *Modern Electric and Gas Refrigeration* book was revised every three to five years as new equipment was developed. The title of the book was eventually changed to *Modern Refrigeration and Air Conditioning*. Mr. Turnquist was an associate member of the American Society of Refrigerating Engineers.

Alfred Bracciano received a bachelor of science degree in Industrial Education with certification in Vocational Education from Wayne State University in Detroit. He also earned a master's degree in Secondary Education and a Specialist degree in Administration and Supervision.

Mr. Bracciano was employed as a teacher of Refrigeration and Air Conditioning for 12 years. He then became Director of Career and Technical Education for Warren Consolidated Schools in Warren, Michigan. He taught Community Resources Workshops for Michigan State University and presented at conferences throughout the country.

Mr. Bracciano was a life member of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Refrigeration Service Engineers Society (RSES), Association for Career and Technical Education (ACTE), and the American Technical Education Association (ATEA).

Dan Bracciano began his career in HVACR at the Warren Schools Career Center, graduating in HVACR. He then attended Oakland Community College specializing in HVACR studies. Dan has worked in the HVACR field performing residential and commercial HVACR installations and service. He obtained a Bachelor of Science degree in Mechanical Engineering from Oakland University in Rochester Hills, Michigan.

Dan has over 25 years of experience working in design, development, and the manufacture of HVAC systems for Mitsubishi Climate Control, Alternative Energy Corporation, and General Motors. He holds several patents in the field, including a patent for a Modular Hermetic HVAC system. Dan is a member of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

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Goodheart-Willcox would like to thank the following members for taking time to share their insight, thoughts, and teaching and industry expertise. Their knowledge and wisdom help inform our thinking. Their passion and commitment inspire us.

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Curriculum Correlations

Modern Refrigeration and Air Conditioning aligns with curriculum standards for HVAC Excellence and ACCE accreditation.

HVAC Excellence is a not-for-profit organization that serves the HVACR industry with the goal of supporting and improving HVACR education and training. HVAC Excellence provides many services to HVACR education and training, including awarding program accreditation, professional certifications, and instructor credentials.

The American Council of Construction Education (ACCE) is a not-for-profit organization with the goal of promoting and improving construction education. ACCE's HVACR Education Program Accreditation (formerly PAHRA accreditation) incorporates industry-validated curriculum standards developed by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI).

To see how *Modern Refrigeration and Air Conditioning* correlates to HVAC Excellence and AHRI standards, please visit https://www.g-w.com/modern-refrigeration-air-conditioning-2025 and click on the Correlations tab. For more information on HVAC Excellence and ACCE, please visit their websites at www.hvacexcellence.org and www.acce-hq.org.

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Reviewers

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New to This Edition

The 22nd edition of *Modern Refrigeration and Air Conditioning* includes many updates, including the following content- and pedagogical-based improvements:

- **Targeted reorganization of chapters and content.** Several chapters and content were moved to better fit typical course offerings in HVACR programs. Thermostat and electrical control content was redistributed so that all controls for various systems (air conditioning, heating, heat pumps, etc.) are included in each respective system's chapter.
- **New Chapter 9, *Basic Refrigeration and Air-Conditioning System Components*.** New chapter integrates all residential refrigeration and air-conditioning components in one chapter to provide an earlier introduction to key system components.
- **Expanded heat pump coverage.** Heat pumps are now covered in two separate chapters with one chapter focusing on the fundamentals and service of air-source heat pumps and the other on the fundamentals and service of geothermal heat pumps.
- **Coverage of key HVACR industry changes.** Changes to HVACR equipment related to SEER2 (Seasonal Energy Efficiency Ratio 2), and refrigerant phasedown and transition toward A2L refrigerants is covered throughout the book. Coverage of indoor air quality and airborne pathogen mitigation has been expanded for this edition.
- **Instructional design improvements.** All learning outcomes, summary bullets, and end-of-chapter review questions were reviewed and aligned with each one-head section in every chapter, allowing for instructor flexibility in presenting and assigning textbook content in the classroom.
- **New lab activities.** Over 100 new lab activities have been added to the package, for a total of over 200 labs. Over 100 lab activities are available in the printed Lab Manual, and over 200 lab activities are available in the digital products. These activities address topics ranging from fundamental service basics to advanced service of commercial systems.
- **New HVACR videos.** For digital users, 35 new videos—for a total of 102 videos—provide hands-on demonstrations and visual instruction of HVACR theory and service topics.
- **New Virtual Toolbox.** This digital product includes e-flash cards, identification and matching activities, and assessments to help students identify key tools used in the HVACR industry.

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Features of the Textbook



The instructional design of this textbook includes student-focused learning tools to help you succeed. This visual guide highlights these features.

Chapter Opening Materials

Each chapter opener contains a list of learning outcomes, a list of technical terms, and an introduction. **Learning Outcomes** clearly identify the knowledge and skills to be gained when the chapter is completed. **Technical Terms** list the key words to be learned in the chapter. **Introduction** provides an overview and preview of the chapter content.

Additional Features

Additional features are used throughout the body of each chapter to further learning and knowledge. **Safety Notes** alert you to potentially dangerous materials and practices. **Cautions** alert you to practices that could potentially damage equipment or instruments. **Code Alerts** point out specific items from typical building codes. **Procedures** are highlighted throughout the textbook to provide clear instructions for hands-on HVACR service activities. **Pro Tips** provide advice and guidance that is especially applicable for on-the-job situations. **Thinking Green** features highlight key items related to sustainability, energy efficiency, and environmental issues.

Illustrations

Illustrations have been designed to clearly and simply communicate specific topics. Illustrations have been reviewed and updated for this edition. Photographic images have been updated to show the latest equipment.

Expanding Your Learning

Soft Skills for HVACR features provide expert advice on developing communication, teamwork, and interpersonal skills useful in the HVACR industry. **Service Call Troubleshooting** features help you develop critical thinking, diagnostic, and troubleshooting skills needed in the HVACR industry today.

End-of-Chapter Content

End-of-chapter material provides an opportunity for review and application of concepts. A concise **Summary** provides an additional review tool and reinforces key learning outcomes. This helps you focus on important concepts presented in the text. **Review Questions** enable you to demonstrate knowledge, identification, and comprehension of chapter material. **Critical Thinking** questions develop higher-level thinking and problem-solving and troubleshooting skills.

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TOOLS FOR STUDENT AND INSTRUCTOR SUCCESS

Student Tools



Student Text

Modern Refrigeration and Air Conditioning is a comprehensive text that focuses on closing the gap from students to technicians with a commitment to top-quality coverage of fundamentals and the latest technology.

Lab Manual

- Hands-on practice includes relevant HVACR service procedures performed in the field.

Workbook

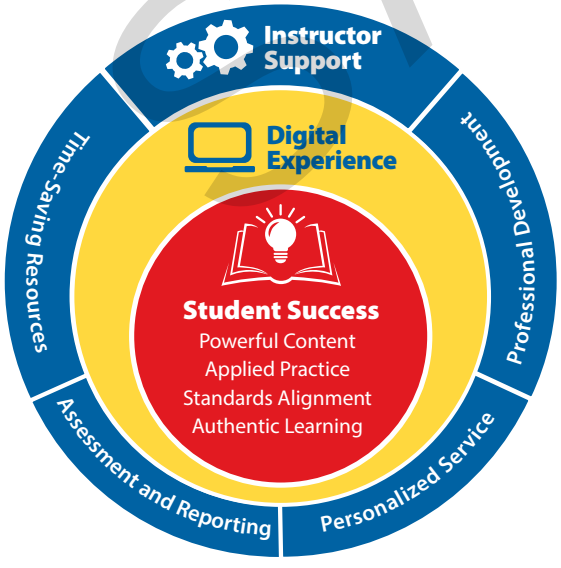
- Questions test knowledge, identification, and comprehension of content presented in the textbook.

Digital Companion

For digital users, e-flash cards, vocabulary exercises, and end-of-chapter Review Questions allow interaction with content to create opportunities to increase achievement.

Online Learning Suite

- Online student text, lab manual, and workbook—along with rich supplemental content—bring digital learning to the classroom.
- HVACR videos and animations provide hands-on demonstrations and visual instruction of HVACR theory, procedures, and service topics.
- Follow-the-Heat™ Animations contain 63 short-story animations that help students understand foundational scientific concepts through simple visuals.
- HVACR Troubleshooting Activities contain over 40 scenarios where students are challenged to systematically troubleshoot various systems.
- Virtual Toolbox provides e-flash cards, matching and identification activities, and assessments to help students identify key tools used in the HVACR industry.
- All instructional materials are accessible at home, at school, or on the go.



Instructor Tools

LMS Integration

Integrate Goodheart-Willcox content within your Learning Management System for a seamless user experience for both you and your students. EduHub® LMS–Ready content in Common Cartridge® format facilitates single sign-on integration and gives you control of student enrollment and data. With a Common Cartridge integration, you can access the LMS features and tools you are accustomed to using and G-W course resources in one convenient location—your LMS.

G-W Common Cartridge provides a complete learning package for you and your students. The included digital resources help your students remain engaged and learn effectively:

- **Digital Textbook**
- Online **Lab Manual activities**
- Online **Workbook content**
- **HVACR videos and animations**
- **Follow-the-Heat™ animations**
- **HVACR Troubleshooting Activities**
- **Virtual Toolbox**
- **Drill and Practice** vocabulary activities

When you incorporate G-W content into your courses via Common Cartridge, you have the flexibility to customize and structure the content to meet the educational needs of your students. You may also choose to add your own content to the course.

For instructors, the Common Cartridge includes the Online Instructor Resources. QTI® question banks are available within the Online Instructor Resources for import into your LMS. These prebuilt assessments help you measure student knowledge and track results in your LMS gradebook. Questions and tests can be customized to meet your assessment needs.

Online Instructor Resources

- The **Instructor Resources** provide instructors with time-saving preparation tools such as answer keys, editable simple and detailed lesson plans, an image library, and other teaching aids.
- **Instructor's Presentations for PowerPoint®** are fully customizable, richly illustrated slides that help you teach and visually reinforce the key concepts from each chapter.
- Administer and manage assessments to meet your classroom needs using **Assessment Software with Question Banks**, which includes hundreds of matching, completion, multiple choice, and short answer questions to assess student knowledge of the content in each chapter.

See www.g-w.com/modern-refrigeration-air-conditioning-2025 for a list of all available resources.

Professional Development

- Expert content specialists
- Research-based pedagogy and instructional practices
- Options for virtual and in-person professional development

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