

# **INDUSTRIAL MAINTENANCE and MECHATRONICS**

SECOND EDITION

**Shawn A. Ballee**

Associate Professor of Industrial Systems Technology  
Waubonsee Community College

**Gary R. Shearer**

Instructor of Industrial Electrical Maintenance  
Tennessee College of Applied Technology-Murfreesboro

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# Preface

*Industrial Maintenance and Mechatronics* covers the many aspects of industrial maintenance and prepares students for careers in a wide variety of industries and occupations. From theory to application, design to diagnosis, and installation to adjustment, you will gain the perspective needed to be successful in a field that is constantly changing due to technological advancement. With straightforward explanations and procedures, this text will serve as a valuable reference for you in both the classroom and workplace.

Advancements in technology and automation have made mechatronics a critical component of industrial maintenance. Mechatronics combines the study of electronics, mechanics, control systems, robotics, and computer software. This mechatronics knowledge is used to design, operate, maintain, and repair “smart” devices and systems that incorporate sensors, actuators, instrumentation, process control, and automation. An understanding of mechatronics will prepare you for career opportunities in a wide range of industries that utilize industrial robots, automated systems, programmable logic controllers, and other mechanical systems.

*Industrial Maintenance and Mechatronics* is the first textbook specifically aligned with the NIMS Industrial Technology Maintenance (ITM) Smart Standards and certifications. These standards—developed with input from a nationwide team of industry and education leaders—provide a clear picture of the knowledge and skills needed by industrial maintenance technicians in today’s workplace. Modeled specifically after these standards, *Industrial Maintenance and Mechatronics* applies not only to manufacturing but to all fields that fall under the umbrella of mechanical, electrical, and electronic systems control and maintenance. Due to its broad coverage, *Industrial Maintenance and Mechatronics* can be used as a primary text for multiple courses in an Industrial Maintenance program.

Numerous in-text examples, procedures, review questions, diagrams, and artwork reinforce key concepts. Safety Notes and Tech Tips highlight key bits of knowledge particularly applicable and critical in the workplace. Troubleshooting methodology is emphasized throughout *Industrial Maintenance and Mechatronics* (including several dedicated troubleshooting chapters) to ensure you become a problem solver who can determine the true cause of a problem, rather than merely a “parts changer.”

NIMS offers a set of seven national, industry-created, industry-recognized Smart credentials for Industrial Technology Maintenance (ITM), as well as their classic ITM credentials. In order to attain a NIMS credential, candidates must pass a written assessment on theory and also complete a hands-on skill assessment under a qualified instructor or supervisor. *Industrial Maintenance and Mechatronics* works hand-in-glove with the NIMS standards to help students successfully achieve NIMS credentials.

This area of study is both wide-ranging and challenging. While this text could have been literally thousands of pages, it has been condensed to highlight core knowledge in the key maintenance disciplines: maintenance operations, basic mechanical systems, basic hydraulic and pneumatic systems, electrical systems, electronic control systems, process control systems, and maintenance piping. Technology is constantly advancing in many of these subjects, and it is expected that this book will undergo revisions and updates to keep pace with those advancements.

# About the Authors

**Shawn Ballee** is Associate Professor of Industrial Systems Technology at Waubonsee Community College in Sugar Grove, Illinois, where he has taught since 1995. His teaching responsibilities have included classes in motor controls, PLCs, hydraulics, pneumatics, mechanical power transmission, power distribution, mathematics, HVAC, and welding. He has extensive industry experience as an electrical and electronics technician and as a consulting maintenance technician for local manufacturers. Mr. Ballee holds a BS degree in Industrial Technology from Northern Illinois University and an MEd in Post-Secondary Mathematics from Concordia University. Mr. Ballee is a member of the NIMS Advisory Council and has served on MSSC's National Expert Panel. He is also an OSHA authorized General Industry safety trainer (10/30 hr.), EPA 608 and 609 certified, and a member of MENSA.

**Gary Shearer** is an Instructor of Industrial Electrical Maintenance at Tennessee College of Applied Technology (TCAT)-Murfreesboro. Since joining the faculty of TCAT, Mr. Shearer has taught a wide range of technical classes, including electricity, electronics, mechanical systems, machine tool, welding, process control, motor control, PLCs, robotics, HVAC, fluid power, industrial/residential wiring, electrical test equipment, troubleshooting, safety, and print reading. Previously, he worked as a senior test engineer for ReMedPar, a medical equipment and parts organization, and as an R&D engineer at Vanderbilt University's W. M. Keck Foundation Free Electron Laser Center. Intellectual property created by Mr. Shearer includes a US patent and an extensive list of technical and scientific publications. He served as a member of the NIMS Technical Working Group that prepared the *Industrial Technology Maintenance Duties and Standards*.

## Contributors

The authors and publisher wish to thank the following teaching professionals for their valuable contributions to *Industrial Maintenance and Mechatronics*:

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Lorain County Community College  
Elyria, OH

**Dale Ballard**

Prairie State College  
Chicago Heights, IL

**Neil Barker**

Moraine Valley Community College  
Palos Hills, IL

**Bob Bender**

Riverland Community College  
Albert Lea, MN

**Jeff Bixby**

Dunwoody College of Technology  
Minneapolis, MN

**Brent Childers**

Amarillo College  
Amarillo, TX

**David Clark**

Western Iowa Tech Community  
College  
Sioux City, IA

**Paul Dettmann**

South Central College  
North Mankato, MN

**Charles J. Eckard**

North Seattle College  
Seattle, WA

**William Fitts**

Holmes Community College  
Ridgeland, MS

**James Frady**

Catawba Valley Community College  
Lawndale, NC

**Thomas W. Fry**

Pennsylvania College of Technology  
Williamsport, PA

**Mike Gallimore**

Tennessee College of Applied  
Technology  
Knoxville, TN

**Tom Groner**

Muskegon Community College  
Muskegon, MI

**Gary E. Hall**

Ivy Tech Community College  
Fort Wayne, IN

**William Hargrove**

Florence-Darlington Technical  
College  
Florence, SC

**Frank R. Holcomb**

Tennessee College of Applied  
Technology  
Paris, TN

**Pete Lomeli**

Central Arizona College  
Coolidge, AZ

**Ron McGary**

Industrial Systems Technology  
Training and Consulting  
Albany, GA

**Thann Mughmaw**

Ivy Tech Community College  
Kokomo, IN

**David Perkins**

Trident Technical College  
Charleston, SC

**Gerald Pilliteri**

Jefferson Technical and Community  
College  
Shelbyville, KY

**Mark Prosser**

Ferris State University  
Big Rapids, MI

**Christopher Rogers**

Southwest Tennessee Community  
College  
Memphis, TN

**David Schaafsma**

Green River College  
Auburn, WA

**Chris Sewalson**

Western Iowa Tech Community  
College  
Sioux City, IA

**Richard Skelton**

Jackson State Community College  
Jackson, TN

**Gregory D. Spence**

Ivy Tech Community College  
Logansport, IN

**Tim Tewalt**

Chippewa Valley Technical College  
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**Ed VanAvery**

Delgado Community College  
New Orleans, LA

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# New to This Edition

This new edition of *Industrial Maintenance and Mechatronics* continues its exclusive partnership with NIMS, with text aligned to the NIMS Industrial Technology Maintenance (ITM) Smart Standards. New and expanded end-of-chapter reviews enhance students' preparation for NIMS certifications, with Know and Understand questions to reinforce key facts and open-ended Apply and Analyze and Critical Thinking questions, where troubleshooting is a focus.

Electrical content has been added and expanded, including two new chapters: *Electrical Production and Distribution* and *Electrical Installation and Practices*. Content has been updated throughout, with the addition of new charts, illustrations, and photographs.

## Credentialing Partners and Support

Goodheart-Willcox appreciates the value of industry credentials, certifications, and accreditation. We are pleased to partner with leading organizations to support students and programs in achieving credentials. Integrating industry-recognized credentialing into a career and technical education (CTE) program provides many benefits for the student and for the institution. By achieving third-party certificates, students gain confidence, have proof of a measurable level of knowledge and skills, and earn a valuable achievement to include in their résumés. For educators and administrators, industry-recognized credentials and accreditation validate learning, enhance the credibility of programs, and provide valuable data to measure student performance and help guide continuous program improvement.

## NIMS Industrial Technology Maintenance (ITM) Credentials

NIMS offers seven Industrial Technology Maintenance (ITM) Smart credentials, as well as Classic ITM credentials. These credentials provide students and working technicians a recognized method to validate their knowledge and skills. *Industrial Maintenance and Mechatronics* is designed to work hand-in-glove with the NIMS standards to help students pass the testing and performance requirements for NIMS credentialing. For more information about NIMS and their Industrial Technology Maintenance (ITM) credentials, visit [www.nims-skills.org](http://www.nims-skills.org).





# 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.

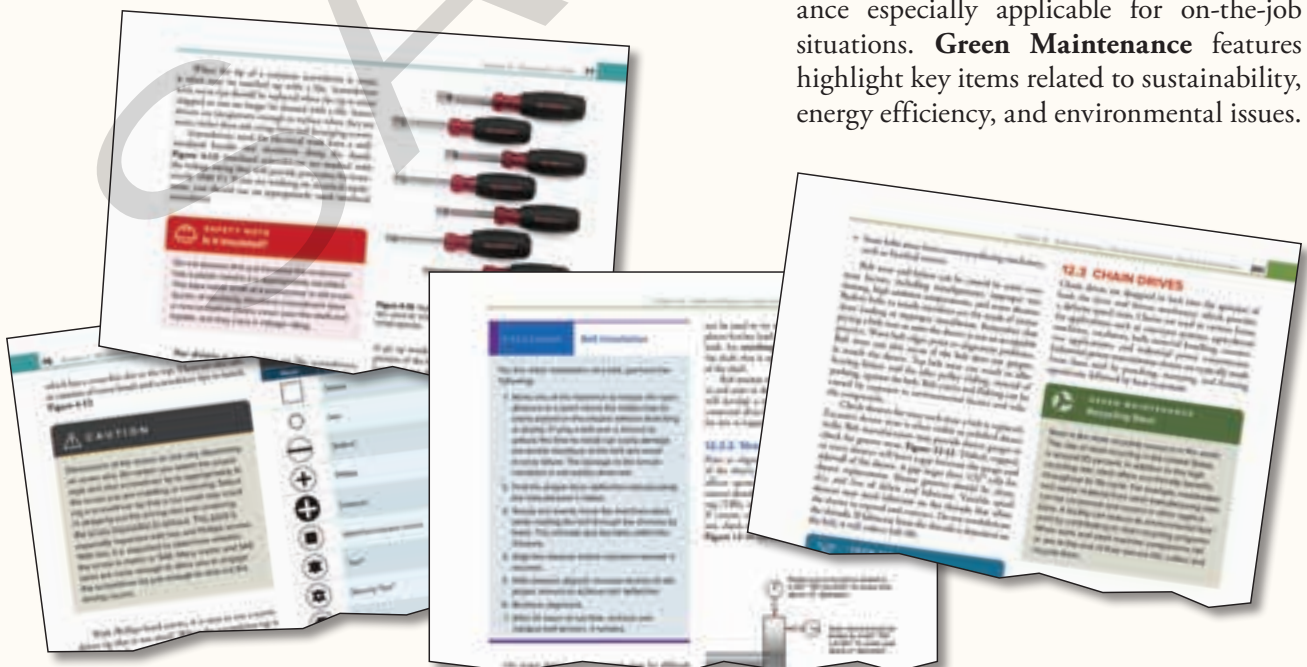


## Chapter Opening Materials

Each chapter opener contains a chapter outline, a list of learning objectives, and a list of technical terms. The **Chapter Outline** summarizes the topics that will be covered in the chapter. **Learning Objectives** 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.

## Additional Features

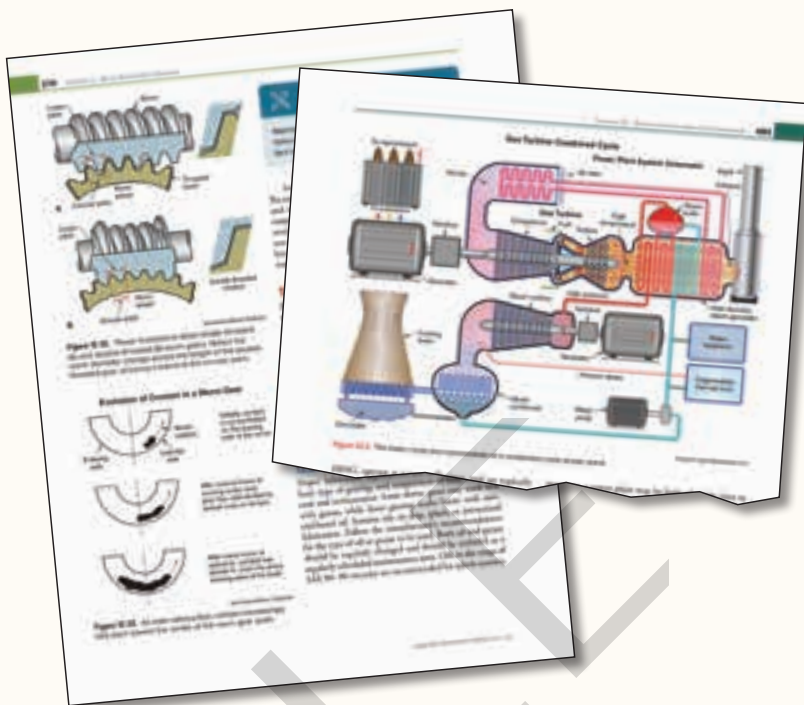
Additional features are used throughout the body of each chapter to further learning and knowledge. **Safety Notes** alert you to potentially dangerous materials and practices. **Cautions** alert you to practices that could potentially damage equipment or instruments. **Procedures** are highlighted throughout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





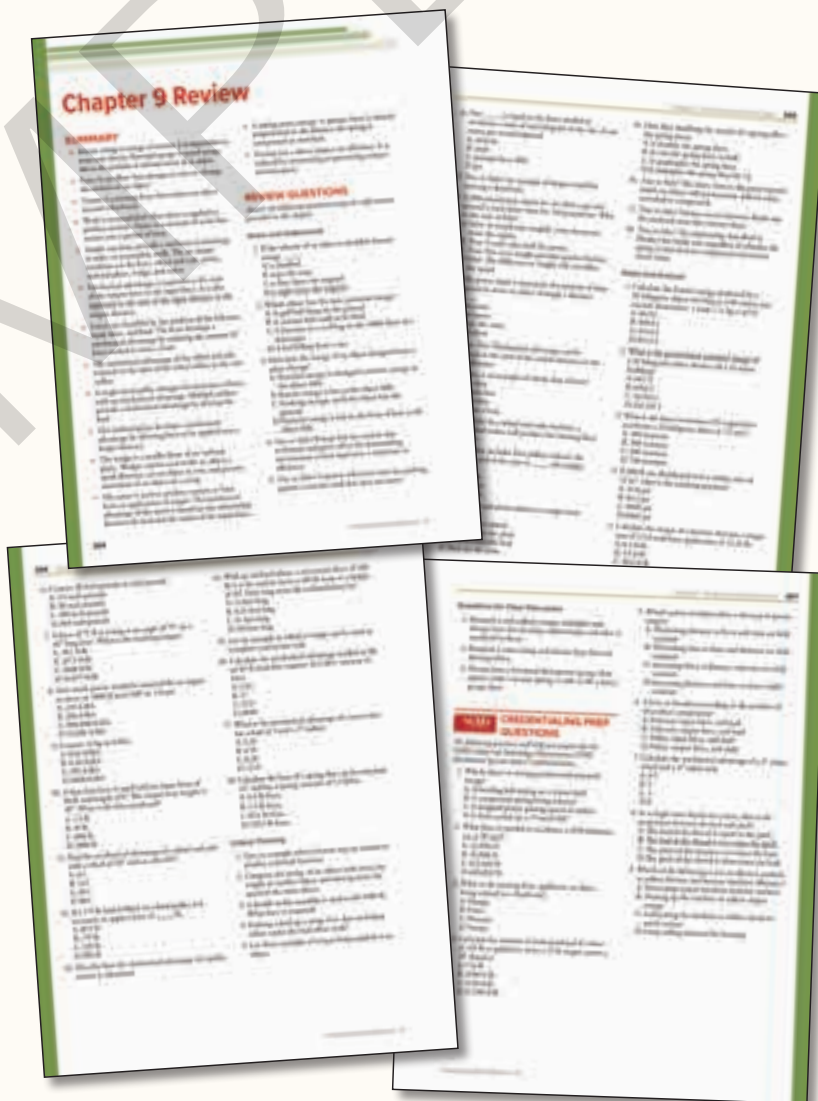
## Illustrations

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



## 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 objectives. This helps you focus on important concepts presented in the text. **Know and Understand** questions enable you to demonstrate knowledge, identification, and comprehension of chapter material. **Apply and Analyze** questions extend learning and develop your abilities to use learned material in new situations and to break down material into its component parts. **Critical Thinking** questions develop higher-order thinking and problem-solving, personal, and workplace skills. **Questions for Class Discussion** extend your learning by allowing further exploration, research, and discussion of topics covered in the chapter. **NIMS Credentialing Prep Questions** help prepare you to successfully achieve NIMS Industrial Technology Maintenance (ITM) credentials.



# TOOLS FOR STUDENT AND INSTRUCTOR SUCCESS

## Student Tools

### Student Text

*Industrial Maintenance and Mechatronics* is a comprehensive text that focuses on the information, techniques, processes, and procedures used by professional industrial maintenance technicians.



### Lab Workbook

- Hands-on practice includes questions and activities.
- Projects offer students opportunities to work on various industrial maintenance challenges.

### G-W Digital Companion

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

### Online Learning Suite

- Online student text and lab workbook, along with rich supplemental content, brings digital learning to the classroom.
- 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**
- **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

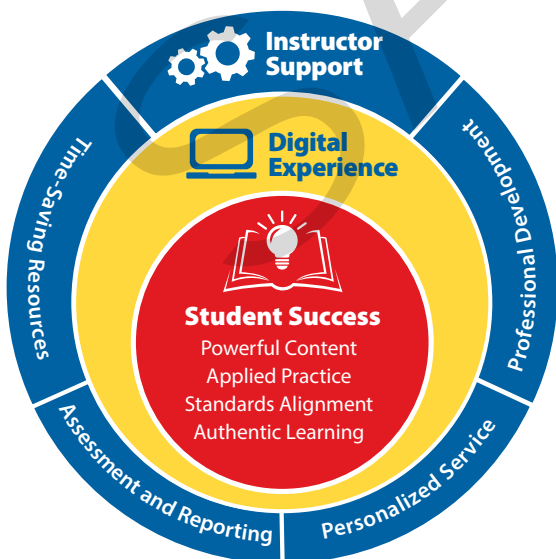
- The **Instructor Resources** provide instructors with time-saving preparation tools such as answer keys, editable lesson plans, and other teaching aids.
- **Instructor's Presentations for PowerPoint®** are fully customizable, richly illustrated slides that help you teach and visually reinforce the key concepts from each chapter.
- Administer and manage assessments to meet your classroom needs using **Assessment Software with Question Banks**, which include 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/industrial-maintenance-mechatronics-2024](http://www.g-w.com/industrial-maintenance-mechatronics-2024) 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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