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) 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 ten national, industry-created, industry-recognized credentials for Industrial Technology Maintenance (ITM). 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* aligns closely 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, maintenance piping, and semiconductor manufacturing. 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.

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About the Authors

Shawn Ballee, Associate Professor of Industrial Systems Technology, retired from Waubonsee Community College in Sugar Grove, Illinois, after 28 years of teaching. During that time, he taught classes in several technology, automation, and mathematic areas. He has extensive experience as an electrical and electronics technician and has performed consulting services for manufacturers. Mr. Ballee holds a bachelor of science degree in Industrial Technology from Northern Illinois University and a master of education degree in Post-Secondary Mathematics from Concordia University. Mr. Ballee has been a member of the NIMS advisory council, served on MSSC's National Expert Panel (safety), and is an OSHA-authorized General Industry safety trainer. He is EPA 608/609 certified and a member of MENSA. He currently concentrates on research and writing.

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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) Standards. Reflecting the updates to the ITM Standards, the third edition has been updated to include two new chapters: Semiconductor Equipment Technician and Semiconductor Facilities Technician. 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. There are also questions used to encourage further research and develop class discussion. Additionally, content has been updated throughout, with the addition of new charts, illustrations, and photographs.

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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 ten Industrial Technology Maintenance (ITM) credentials. These credentials provide students and working technicians with 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.

To see how *Industrial Maintenance and Mechatronics* correlates to credentialing and certification standards, visit the Correlations tab at www.g-w.com/industrial-maintenance-mechatronics-2028.

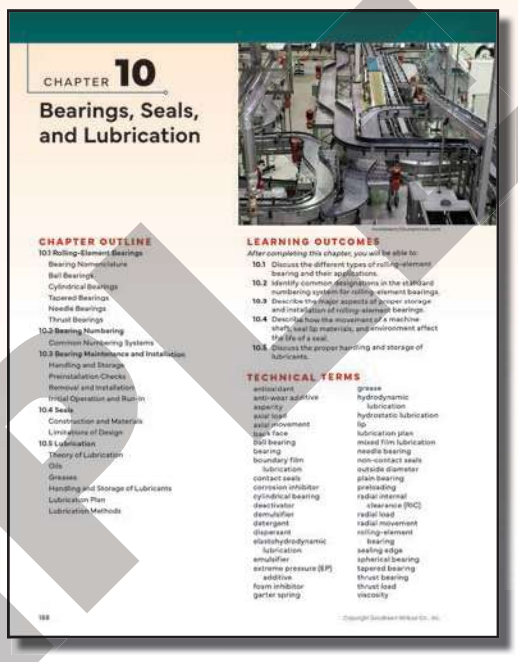
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Features of the Textbook

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 chapter outline, a list of learning outcomes, and a list of technical terms. The **Chapter Outline** summarizes the topics that will be covered in the chapter. **Learning Outcomes** clearly identify the knowledge and skills to be gained when the chapter is completed. These outcomes are labeled and correlated to related assessment elements to facilitate reporting and remediation. **Technical Terms** list the key words to be learned in the chapter.


CHAPTER 10

Bearings, Seals, and Lubrication

CHAPTER OUTLINE

10.1 Rolling-Element Bearings
- Bearing Nomenclature
- Ball Bearings
- Cylindrical Bearings
- Tapered Bearings
- Needle Bearings
- Thrust Bearings

10.2 Bearing Numbering
- Common Numbering Systems

10.3 Bearing Maintenance and Installation
- Handling and Storage
- Preinstallation Checks
- Removal and Installation
- Initial Operation and Run-In

10.4 Seals
- Construction and Materials
- Limitations of Design

10.5 Lubrication
- Theory of Lubrication
- Oils
- Greases
- Handling and Storage of Lubricants
- Lubrication Plan
- Lubrication Methods

LEARNING OUTCOMES

After completing this chapter, you will be able to:

10.1 Discuss the different types of rolling-element bearing and their applications.

10.2 Identify common designations in the standard numbering system for rolling-element bearings.

10.3 Describe the major aspects of proper storage and installation of rolling-element bearings.

10.4 Describe how the movement of a machine shaft, seal to materials, and environment affect the life of a seal.

10.5 Discuss the proper handling and storage of lubricants.

TECHNICAL TERMS

antioxidant
anti-wear additive
axial load
axial movement
back face
ball bearing
boundary film lubrication
contact seals
corrosion inhibitor
cylindrical bearing
deactivator
demulsifier
detergent
dispersant
elastohydrodynamic lubrication
emulsifier
extreme pressure (EP) additive
foam inhibitor
garter spring
grease
hydrodynamic lubrication
hydrostatic lubrication
lip
lubrication plan
mixed film lubrication
needle bearing
non-contact seals
outside diameter
plain bearing
preloading
radial internal clearance (RIC)
radial load
radial movement
rolling-element bearing
sealing edge
spherical bearing
tapered bearing
thrust bearing
thrust load
viscosity

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 that is especially applicable for on-the-job situations.


Continuity Test Mode

CAUTION

Never connect a DMM in the continuity test mode to an energized circuit, or the DMM may be irreparably damaged.

Advanced DMM Functions

Figure 20-14. This DMM display includes a bar graph along the lower portion of the display area. The bar graph provides a visual representation of the fluctuations in the reading.

Figure 20-15. With a thermocouple attached, this DMM can measure temperature.

Thermocouples

A thermocouple is a device that uses the junction of dissimilar metals to generate a voltage proportional to the temperature.

Manually Mounting a Tapered Bearing

Figure 10-21. A dial indicator must be placed to determine the distance to drive up the shaft or shaft sleeve to obtain the proper reduction in internal clearance.

Initial Operation and Run-In

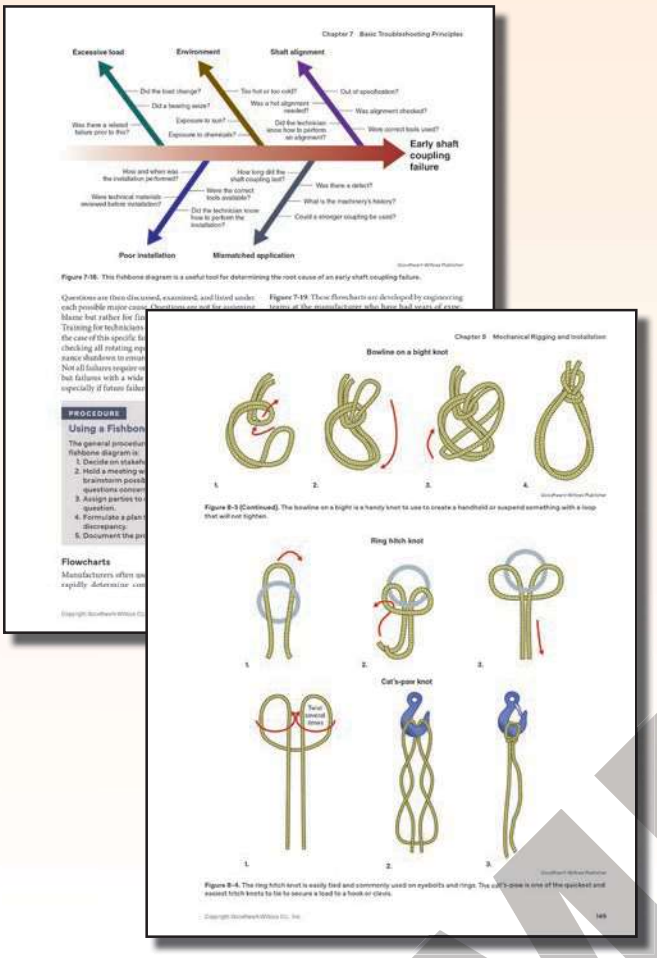
Drives

Belts

Pinch Points

Pinch points are places between moving parts or between a moving part and a stationary part within a machine where loose clothing and body parts can be caught. If not properly guarded, pinch points may cause serious bodily injury, in addition to damaging tools and clothing. Never operate a machine without the safety guards in place. Always reinstall the machine guards after maintenance and before starting any machine.

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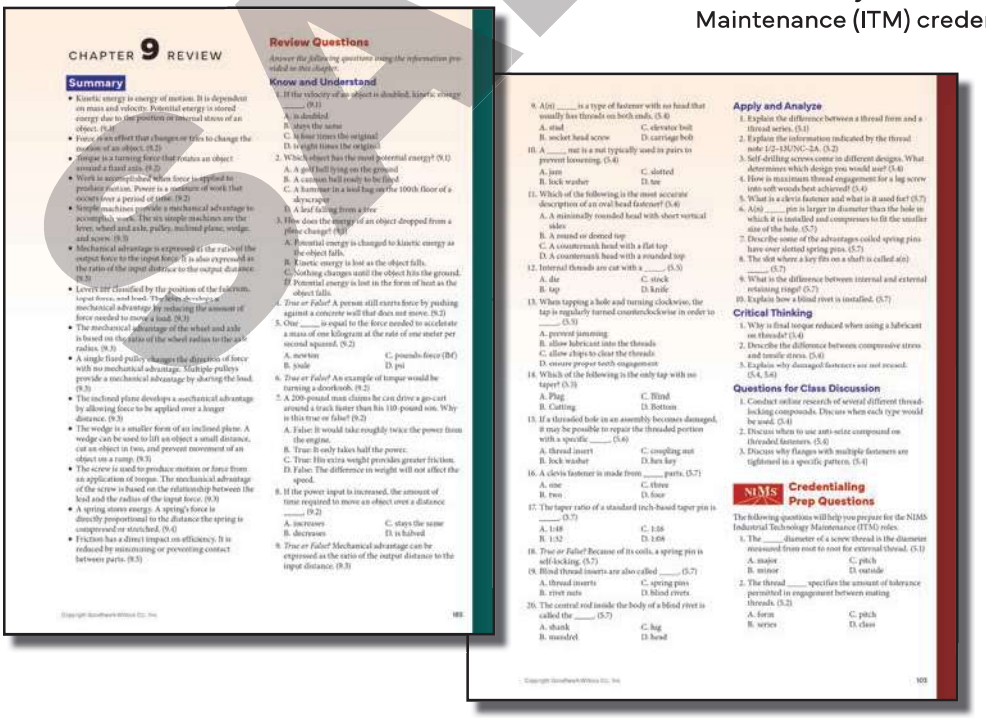


Illustrations

Illustrations have been designed to clearly and simply communicate the specific topic. Illustrations have been 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 outcomes. 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 abilities. **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 attain NIMS Industrial Technology Maintenance (ITM) credentials.



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