PREFACE

APPROACH

The formal boundaries of traditional engineering disciplines have become fuzzy following the advent of integrated circuits and computers. Nowhere is this more evident than in mechanical and electrical engineering, where products today include an assembly of interdependent electrical and mechanical components. The field of mechatronics has broadened the scope of the traditional field of electromechanics. *Mechatronics* is defined as the field of study involving the analysis, design, synthesis, and selection of systems that combine electronic and mechanical components with modern controls and microprocessors.

This book is designed to serve as a text for (1) a modern instrumentation and measurements course, (2) a hybrid electrical and mechanical engineering course replacing traditional circuits and instrumentation courses, (3) a stand-alone mechatronics course, or (4) the first course in a mechatronics sequence. The second option, the hybrid course, provides an opportunity to reduce the number of credit hours in a typical mechanical engineering curriculum. Options 3 and 4 could involve the development of new interdisciplinary courses and curricula.

Currently, many curricula do not include a mechatronics course but include some of the elements in other more traditional courses. The purpose of a course in mechatronics is to provide a focused interdisciplinary experience for undergraduates that encompasses important elements from traditional courses as well as contemporary developments in electronics and computer control. These elements include measurement theory, electronic circuits, computer interfacing, sensors, actuators, and the design, analysis, and synthesis of mechatronic systems. This interdisciplinary approach is valuable to students because virtually every newly designed engineering product is a mechatronic system.

NEW TO THE FIFTH EDITION

The fifth edition of *Introduction of Mechatronics and Measurement Systems* has been improved, updated, and expanded beyond the previous edition. Additions and new features include:

- Arduino resources and examples added to supplement PIC microcontroller programming.
- Matlab solutions added for all MathCAD analysis files provided in previous editions.
- More microcontroller programming and interfacing examples, including serial communication.
- Expanded coverage of practical circuit and microcontroller-project debugging and troubleshooting advice.

- New section dealing with diode applications.
- New coverage of how to use an A/D reconstruction filter to produce high-fidelity representations of sampled data.
- Expanded section dealing with virtual instrumentation and the NI ELVIS Laboratory Platform.
- More website resources, including Internet links and online video demonstrations, cited and described throughout the book.
- Additional end-of-chapter questions throughout the book provide more homework and practice options for professors and students.
- Corrections and many small improvements throughout the entire book.

Also, the Laboratory Exercises Manual that supplements and supports this book is now available on-line for free and unlimited use by faculty and students. It is located, along with video demonstrations, on the Lab Book web page at: ***mechatronics.colostate.edu/lab_book.html***

CONTENT

Chapter 1 introduces mechatronic and measurement system terminology. Chapter 2 provides a review of basic electrical relations, circuit elements, and circuit analysis. Chapter 3 deals with semiconductor electronics. Chapter 4 presents approaches to analyzing and characterizing the response of mechatronic and measurement systems. Chapter 5 covers the basics of analog signal processing and the design and analysis of operational amplifier circuits. Chapter 6 presents the basics of digital devices and the use of integrated circuits. Chapter 7 provides an introduction to microcontroller programming and interfacing, and specifically covers the PIC microcontroller and PicBasic Pro programming. Chapter 8 deals with data acquisition and how to couple computers to measurement systems. Chapter 9 provides an overview of the many sensors common in mechatronic systems. Chapter 10 introduces a number of devices used for actuating mechatronic systems. Finally, Chapter 11 provides an overview of mechatronic system control architectures and presents some case studies. Chapter 11 also provides an introduction to control theory and its role in mechatronic system design. The appendices review the fundamentals of unit systems, statistics, error analysis, and mechanics of materials to support and supplement measurement systems topics in the book.

It is practically impossible to write and revise a large textbook without introducing errors by mistake, despite the amount of care exercised by the authors, editors, and typesetters. When errors are found, they will be published on the book website at: **mechatronics.colostate.edu/book/corrections_5th_edition.html.** You should visit this page now to see if there are any corrections to record in your copy of the book. If you find any additional errors, please report them to *David.Alciatore@colostate.edu* so they can be posted for the benefit of others. Also, please let me know if you have suggestions or requests concerning improvements for future editions of the book. Thank you.

LEARNING TOOLS

Class discussion items (CDIs) are included throughout the book to serve as thought-provoking exercises for the students and instructor-led cooperative learning activities in the classroom. They can also be used as out-of-class homework assignments to supplement the questions and exercises at the end of each chapter. Hints and partial answers for many of the CDIs are available on the book website at **mechatronics.colostate.edu.** Analysis and design examples are also provided throughout the book to improve a student's ability to apply the material. To enhance student learning, carefully designed laboratory exercises coordinated with the lectures should accompany a course using this text. A supplemental Laboratory Exercises Manual is available for this purpose (see **mechatronics.colostate.edu/lab_book.html** for more information). The combination of class discussion items, design examples, and laboratory exercises exposes a student to a real-world practical approach and provides a useful framework for future design work.

In addition to the analysis Examples and design-oriented Design Examples that appear throughout the book, Threaded Design Examples are also included. The examples are mechatronic systems that include microcontrollers, input and output devices, sensors, actuators, support electronics, and software. The designs are presented incrementally as the pertinent material is covered throughout the chapters. This allows the student to see and appreciate how a complex design can be created with a divide-and-conquer approach. Also, the threaded designs help the student relate to and value the circuit fundamentals and system response topics presented early in the book. The examples help the students see the "big picture" through interesting applications beginning in Chapter 1.

ACKNOWLEDGMENTS

To ensure the accuracy of this text, it has been class-tested at Colorado State University and the University of Wyoming. I'd like to thank all of the students at both institutions who provided me valuable feedback throughout this process. In addition, I'd like to thank my many reviewers for their valuable input.

YangQuan Chen *Utah State University*
Meng-Sang Chew *Lehigh University*
Mo-Yuen Chow *North Carolina State University*
Burford Furman *San José State University*
Venkat N. Krovi *State University of New York, Buffalo*
Satish Nair *University of Missouri*
Ramendra P. Roy *Arizona State University*
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David Walrath *University of Wyoming*

I'd also like to thank all of the users and readers who have sent in corrections and recommendations for improvement via email. This input has helped me make the new edition of the book better and as error-free as possible for everyone.

ABOUT THE AUTHOR

Dr. David G. Alciatore has been a mechanical engineering professor at Colorado State University (CSU) since 1991. Dr. Dave, as his students know him, is a dedicated teacher and has received numerous awards for his contributions, including the university-wide Board of Governors "Excellence in Undergraduate Teaching Award." His major research, consulting, and teaching interests include modeling and simulation of dynamic systems, mechatronic system design, high-speed video motion analysis, and engineering education. Over his career, Dr. Dave has done research and consulting dealing with robotics, computer graphics modeling, rapid prototyping (3D printing), sports mechanics, and mechatronics.

Dr. Dave has a PhD (1990) and an MS (1987) in Mechanical Engineering from the University of Texas at Austin, and a BS (1986) in Mechanical Engineering from the University of New Orleans. He has been an active member of the American Society of Mechanical Engineers (ASME) since 1984 and has served on many ASME committees, boards, and task forces. He also served as an ASME *Distinguished Lecturer*, and is a *Fellow* of the society. He is also a Professional Engineer.

In addition to his interest in mechatronics, Dr. Dave is passionate about the physics and engineering of billiards equipment and techniques. He is author of the book: *The Illustrated Principles of Pool and Billiards* and has published numerous instructional-video DVDs dealing with understanding and playing the wonderful game of pool. He also writes a monthly column for *Billiards Digest* magazine and has a very active pool-related YouTube Channel. Dr. Dave incorporates his passion for pool into the engineering classroom every chance he gets (e.g., when he teaches Advanced Dynamics).

If you have used this book in the past, you will notice that a second author is no longer listed. Dr. Dave co-authored earlier editions of this book with Michael B. Histand. Dr. Histand retired in 2005 after a 37-year career at Colorado State University. Dr. Dave has worked on the last two editions of this book on his own; but in the early editions, Dr. Histand contributed a wealth of knowledge and experience dealing with electronics, sensors, and instrumentation. Dr. Dave will always cherish the time he spent with Mike, and he sincerely thanks him for the many enjoyable years working together. He and Mike are good friends and still see each other on a regular basis.

SUPPLEMENTAL MATERIALS ARE AVAILABLE ONLINE AT:
mechatronics.colostate.edu

Cross-referenced visual icons appear throughout the book to indicate where additional information is available on the book website at **mechatronics.colostate.edu.**

Shown below are the icons used, along with a description of the resources to which they point:

Video Demo

This sign indicates where an online video demonstration is available for viewing. The online videos are YouTube videos or Windows Media (WMV) files viewable in an Internet browser. The clips show and describe electronic components, mechatronic devices and system examples, and as well as laboratory exercise demonstrations.

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Internet Link

This sign indicates where a link to additional Internet resources is available on the book website. These links provide students and instructors with reliable sources of information for expanding their knowledge of certain concepts.

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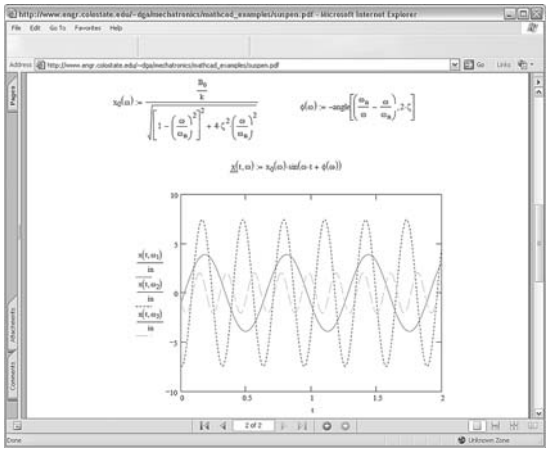
This sign indicates where Mathcad/Matlab files are available for performing analysis calculations. The files can be edited to perform similar and expanded analyses. PDF versions are also posted for those who do not have access to Mathcad/Matlab software.

MATLAB® examples



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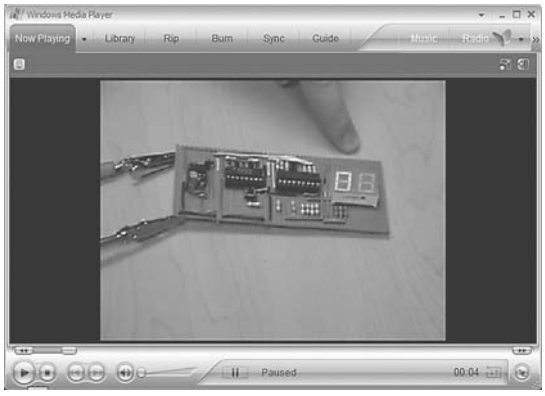
This sign indicates where a laboratory exercise is available in the supplemental Laboratory Exercises Manual that parallels the book. The manual provides useful hands-on laboratory exercises that help reinforce the material in the book and allow students to apply what they learn. Resources and short video demonstrations of most of the exercises are available on the book website. For information about the Laboratory Exercises Manual, visit **mechatronics.colostate.edu/lab_book.html.**

Lab Exercise



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ADDITIONAL SUPPLEMENTS

More information, including a recommended course outline, a typical laboratory syllabus, Class Discussion Item hints, and other supplemental material, is available on the book website.

In addition, a complete password-protected Solutions Manual containing solutions to all end-of-chapter problems is available at the McGraw-Hill book website at **www.mhhe.com/alciatore.**

These supplemental materials help students and instructors apply concepts in the text to laboratory or real-world exercises, enhancing the learning experience.