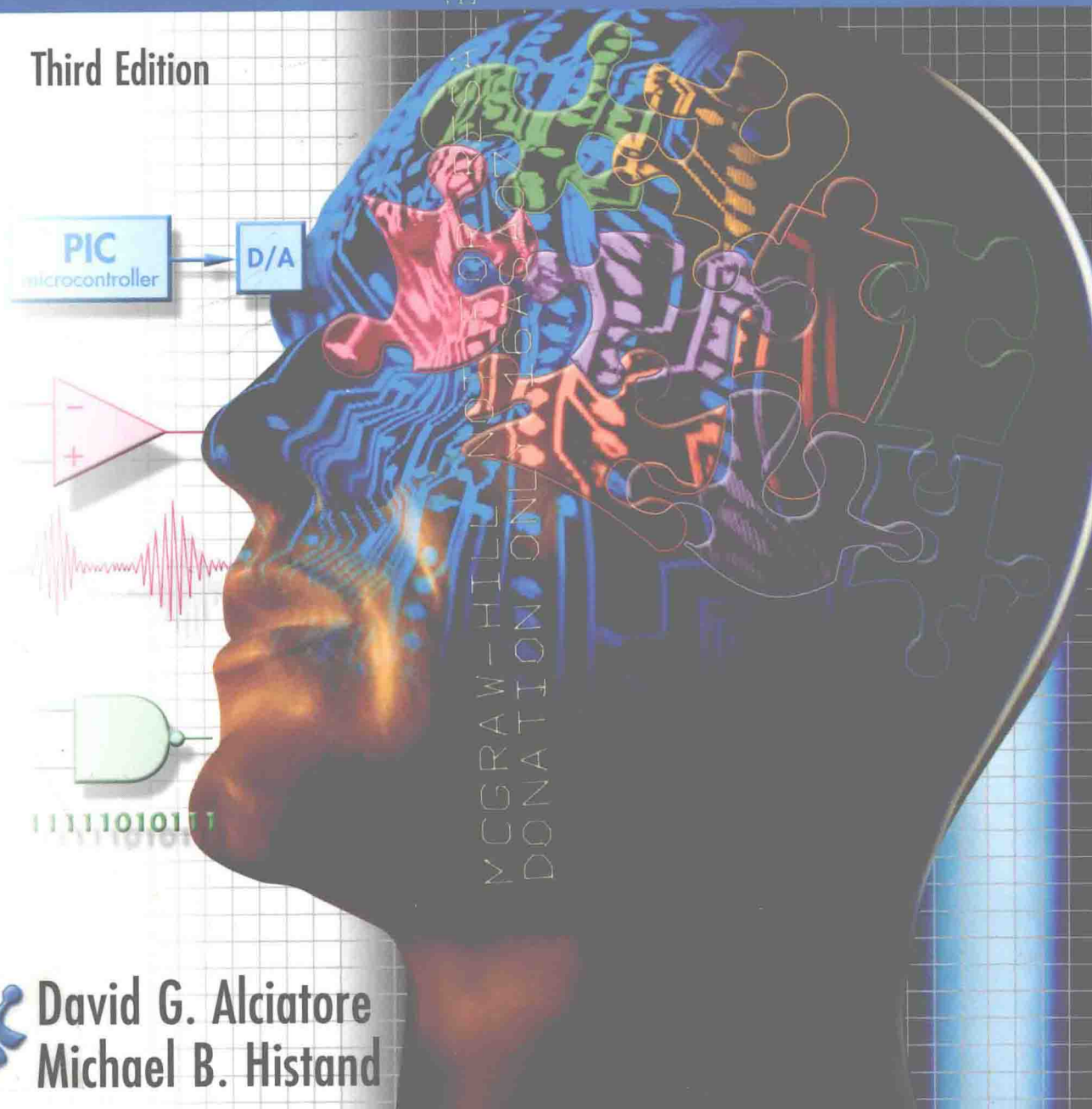


Introduction to

# MECHATRONICS

and Measurement Systems

Third Edition



David G. Alciatore  
Michael B. Hstand

# Introduction to Mechatronics and Measurement Systems

**Third Edition**

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## 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.

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 THIRD EDITION

The third edition of *Introduction to Mechatronics and Measurement Systems* has been modernized and updated throughout and includes expanded coverage of many areas, as well as several new features, such as:

- More coverage of microcontroller hardware and software design examples emphasizing the interface to mechatronic system components, including new Threaded Design Examples throughout the text and a new detailed case study in Chapter 11
- New visual icons throughout the book marking cross-references to extensive online resources including video demonstrations, MathCAD examples, laboratory exercises, and Internet links to useful information

- Many new photographs and descriptions of real mechatronic systems and devices
- An expanded chapter on data acquisition with a brief introduction to LabView
- A new introduction to controls theory and its application in mechatronic systems

A more detailed description of some of these new features appears in the following sections.

## **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.

## **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. 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 the book website 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. These are new to the third edition. 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. We’d like to thank all of the students at both institutions who provided us valuable feedback throughout this process. In addition, we’d like to thank our many reviewers for their valuable input.

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# SUPPLEMENTAL MATERIALS ARE AVAILABLE ONLINE AT: [www.engr.colostate.edu/mechatronics](http://www.engr.colostate.edu/mechatronics)

New to the third edition of *Introduction to Mechatronics and Measurement Systems*, cross-referenced visual icons appear throughout the book to indicate where additional information is available on the book website at [www.engr.colostate.edu/mechatronics](http://www.engr.colostate.edu/mechatronics).

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



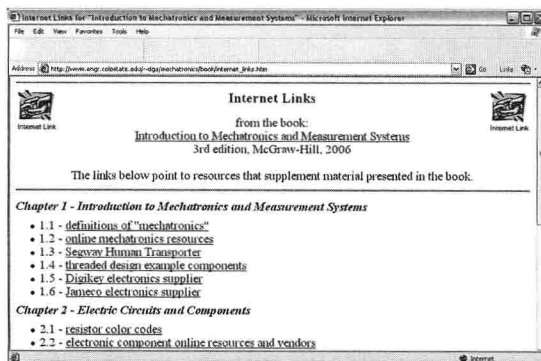
Video Demo

Indicates where an online video demonstration is available for viewing. The online videos are Windows Media (WMV) files viewable in an Internet browser. The clips show and describe electronic components, mechatronic device and system examples, and laboratory exercise demonstrations.

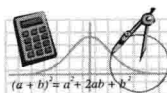


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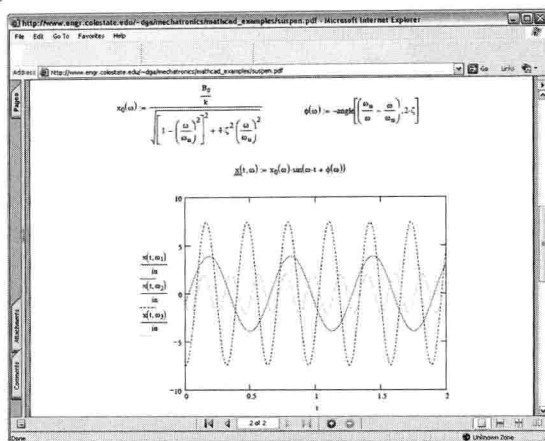
Indicates where a link to additional Internet resources is available on the book website. These links provide students and instructors with reliable sources of information for expanding their knowledge of certain concepts.



Indicates where MathCAD 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 don't have access to MathCAD software.



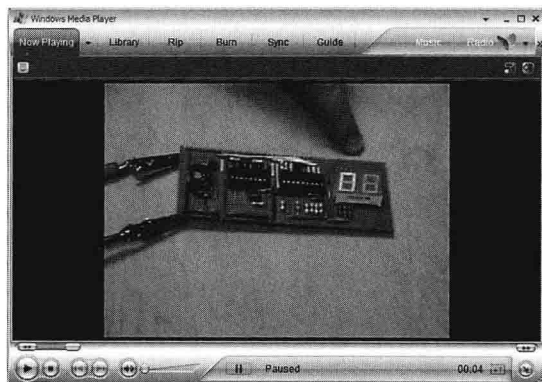
**MathCAD Example**



Indicates where a laboratory exercise is available in the supplemental Laboratory Exercises Manual (ISBN: 0-07-297875-9) that parallels the book. The manual provides useful hands-on laboratory exercises that help reinforce the material in the book and that 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 [www.engr.colostate.edu/mechatronics/lab\\_book.html](http://www.engr.colostate.edu/mechatronics/lab_book.html).



**Lab Exercise**



## 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](http://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.

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