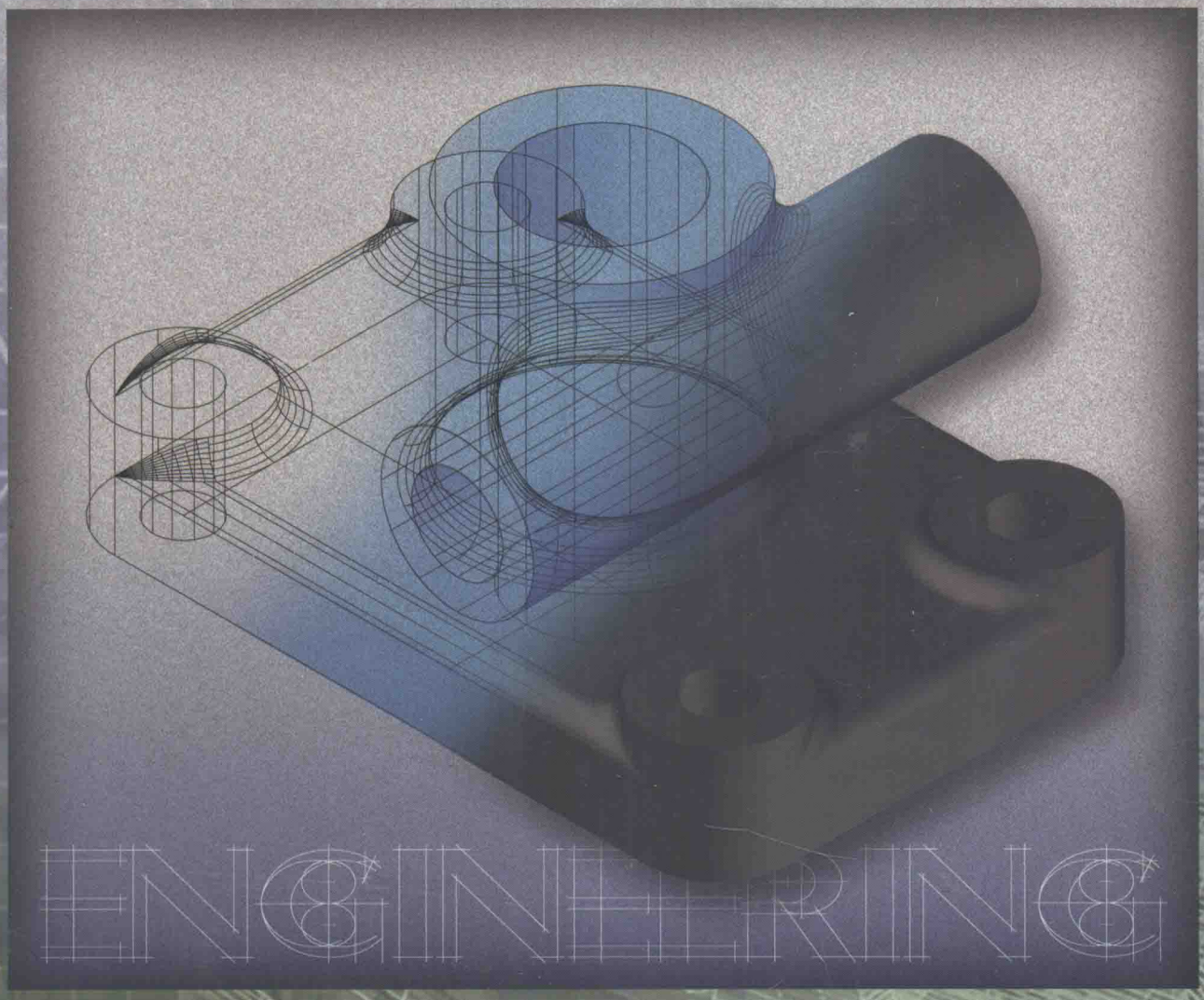
# ENGINEERING DRAWING & DESIGN

Seventh Edition




Cecil Jensen • Jay D. Helsel • Dennis R. Short

# ENGINEERING Drawing & Design

Seventh Edition


**Cecil Jensen**
Former Technical Director
R.S. McLaughlin Collegiate and Vocational Institute
Oshawa, Ontario, Canada

**Jay D. Helsel**
Professor and Chairman Emeritus
Department of Applied Engineering and Technology
California of Pennsylvania
California, University Pennsylvania

**Dennis R. Short**
Professor of Computer Graphics
Department of Computer Graphics Technology
Purdue University
West Lafayette, Indiana





Boston Burr Ridge, IL Dubuque, IA New York San Francisco St. Louis
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto

**McGraw-Hill Higher Education**

ENGINEERING DRAWING AND DESIGN, SEVENTH EDITION



This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 0 QPV/QPV 0 9 8 7

ISBN 978–0–07–352151–0
MHID 0–07–352151–5

Global Publisher: *Raghothaman Srinivasan*
Executive Editor: *Michael Hackett*
Senior Sponsoring Editor: *Bill Stenquist*
Director of Development: *Kristine Tibbetts*
Developmental Editor: *Lorraine K. Buczek*
Outside Developmental Services: *Rose Kernan, RPK Editorial Services*
Executive Marketing Manager: *Michael Weitz*
Project Manager: *Apri l R. Southwood*
Senior Production Supervisor: *Laura Fuller*
Associate Media Producer: *Christina Nelson/Judi David*
Designer: *Laurie B. Janssen*
(USE) Cover Image: *Digital Vision/Getty Images*
Senior Photo Research Coordinator: *John C. Leland*
Photo Research: *Editorial Image, LLC*
Supplement Producer: *Melissa M. Leick*
Compositor: *Aptara, Inc.*
Typeface: *10/12 Times*
Printer: *Quebecor World Versailles, KY*

The credits section for this book begins on page C-1and is considered an extension of the copyright page.

**Library of Congress Cataloging-in-Publication Data**

Jensen, Cecil Howard, 1925-
Engineering drawing and design / Cecil Jensen, Jay D. Helsel, Dennis R. Short.—7th ed.
p. cm.
Includes index.
ISBN 978-0-07-352151-0—ISBN 0-07-352151-5 (hard copy : alk. paper)
1. Mechanical drawing. 2. Engineering design. I. Helsel, Jay D. II. Short, Dennis R., Professor. III. Title.
T353.J47 2008
604.2--dc22

2007021880

# Preface

*Engineering Drawing and Design, Seventh Edition,* prepares students for drafting careers in modern, technology-intensive industries. Technical drafting, like all technical areas, is constantly changing; the computer has revolutionized the way in which drawings and parts are made. This new edition translates the most current technical information available into the most useful for both instructor and student. The book covers graphic communication, CAD, functional drafting, material representation, shop processes, geometric tolerancing, true positioning, numerical control, electronic drafting, and metrication. The authors synthesize, simplify, and convert complex drafting standards and procedures into understandable instructional units.

Like previous editions, this one is at the cutting edge of drafting and computer technologies. Because board-drafting skills are rapidly being replaced by computer-aided drafting (CAD), this edition provides an enhanced view of CAD while adhering to current ASME, ANSI, CSA, and ISO standards. Drafters must be knowledgeable about CAD and about international standards, for design files can now be electronically transmitted across borders, or around the world.

The reader will find that this book helps build basic skills. It also supplies the technical knowledge required in today's marketplace.

## TEXT FEATURES

- **Knowing and Applying Drawing Standards.** A drawing made in the United States must meet the requirements set out in various ASME drawing standards publications. Also, if a firm is involved in international marketing and manufacturing, ISO guidelines (or other standards, such as Canadian drawing standards) must be strictly followed. Drafters will be pleased to see that this book not only covers these standards but also shows how to interpret and apply them. For example, the coverage of geometric tolerancing and true position is more comprehensive than in any other drafting text on the market today.
- **Knowing Manufacturing Materials and Their Processes.** The authors bring together and explain the manufacturing materials that are available for engineering design. They describe the manufacturing processes that influence the shape, appearance, and design of the product.
- **Knowing Fastening Methods.** The correct fastening device plays a very important role in the cost, design, and appearance of a product. Readers can learn about various types of fasteners, both permanent and removable, that are currently available.
- **Providing All the Necessary Information to Complete the Design.** The numerous assignments help the reader gain practice. These assignments can be completed with the help of a variety of Appendix tables reflecting real-world applications.
- **Unit Approach in Teaching the Subject Matter.** The text's unit approach makes it possible for instructors to put together a customized program of instruction that suits the needs of their students and local industry.

## KEY FEATURES OF THE SEVENTH EDITION

Many users of the text were consulted before this new edition was undertaken. In response to their suggestions and recommendations, we have made major changes and added new features to this *Seventh Edition,* including:

- The four-color format is easy to read. Color has been used as well to strengthen the important features in the 3000 line drawings and photographs.
- Chapter 2 explains how drawings are produced by computers and peripherals. Computers and the Internet Web have become not only a laboratory but also a limit- less technical resource and design facility.
- Solid modeling continues to play an important role in Chap. 15. The power of personal computers and workstations brings 3-D modeling into the classroom, home, CAD office, and on-site manufacturing centers.
- Chapter 16 contains more information on geometric tolerancing and guidance on how to apply it to various drawings. The chapter is up to date with ASME standards and is more understandable to beginning students.
- Chapter 19 covers concurrent engineering and project modeling. Today, engineers and technicians work side by side. All team members are responsible for coordinating efforts to deliver on-time and on-budget finished products.

- The section on stamping in Chap. 23 it covers the process of forming and cutting thicker-gage metals that are used in manufacturing.
- Chapter 27, on electronic drafting, is consistent with solid-state, printed circuit board technology.
- Many chapters include new CAD features. They give students and instructors a clear picture of how CAD can be used in the classroom while maintaining a focus on basic drafting principles. Many CAD features include assignments.
- We have continued to provide the unit approach to teaching, which divides chapters into "mini" teaching units. Instructors find this approach to be a real bonus. By choosing the appropriate units, instructors can put together a customized program that suits the needs of their students and local industry.
- Design concepts are covered in the text through drawing practice. Graduates find that these concepts give them an excellent background in drafting and design. Instructors can choose the units appropriate for their program.
- This text continues to provide the latest drawing standards, indispensable to instructors. Current ANSI/ASME and ISO drawing practices are examined better here than in any other text.
- Numerous Internet assignments appear throughout the book. The Websites, which relate directly to the topic of the unit, are of companies students might select to survey possible career opportunities. Instructors can ask students to describe what they found at the sites or to discuss sites that have the greatest regional career interest. Students can also view various technical product lines.

Each chapter begins with objectives and ends with a chapter summary and list of key terms (both referenced to chapter units) and draftinvg assignments. A Glossary, precedes the Appendix. The four-color design highlights the text's special features. Color is used to enhance the instructional value of the material. Thus, technical material is appealing visually and easy to follow and understand.

## ADDITIONAL RESOURCES

We have revised, improved, and added to the program's ancillary products. Here is what's new and updated:

### Drawing Workbook

The *Workbook for Engineering Drawing and Design, Seventh Edition,* covers all 27 chapters. It contains worksheets that provide a partially completed solution for assignments for each unit of the text. Each worksheet is referenced to a specific chapter and unit number in the text. Instructions are provided that give an overview for each assignment and references it to the appropriate text unit. The drawing problems contain both U.S. customary (decimal inch) and metric (millimeter) units of measurement. The worksheets are perforated for easy removal. Solutions are available to instructors at the book's website at www.mhhe.com/jensen.

### Additional Chapters on Advanced Topics

Three additional chapters, covering advanced topics, are provided on the book's website:

Chapter 28—Applied Mechanics
Chapter 29—Strength of Materials
Chapter 30—Fluid Power

Comments and suggestions concerning this and future editions of the text are most welcome.

Visit the text website at: www.mhhe.com/jensen for various resources available to instructors and students.

# Acknowledgments

The authors are indebted to the members of ASME Y14.5M–1994 (R2004), *Dimensioning and Tolerancing,* and the members of the CAN/CSA–B78.2-M91, *Dimensioning and Tolerancing of Technical Drawings,* for the countless hours they have contributed to making successful standards.

The authors and staff of McGraw-Hill wish to express their appreciation to the following individuals for their responses to questionnaires and their professional reviews of the new edition:

Fred Brasfield
*Tarrant County College*

Ralph Dirksen
*Western Illinois University*

James Freygang
*Ivy Tech Community College*

George Gibson
*Athens Technical College*

James Haick
*Columbus Technical College*

Richard Jerz
*St. Ambrose University*

Bisi Oluyemi
*Morehouse College*

Robert A. Osnes
*Everett Community College*

Douglas L. Ramers
*University of Evansville*

Jeff Raquet
*University of North Carolina—Charlotte*

Larry Shacklett
*Southeastern Community College*

Warner Smidt
*University of Wisconsin-Platteville*

James Stokes
*Ivy Tech Community College of Indiana*

Slobodan Urdarevik
*Western Michigan University*

Dean Zirwas
*Indian River Community College*

# About the Authors

## Cecil H. Jensen

Cecil H. Jensen authored or coauthored many successful technical books, including *Engineering Drawing and Design, Fundamentals of Engineering Drawing, Fundamentals of Engineering Graphics* (formerly called *Drafting Fundamentals*), *Interpreting Engineering Drawings, Geometric Dimensioning and Tolerancing for Engineering and Manufacturing Technology, Architectural Drawing and Design for Residential Construction, Home Planning and Design,* and *Interior Design.* Some of these books were printed in three languages and are popular in many countries.

Mr. Jensen was a member of the Canadian Standards Committee (CSA) on Technical Drawings (which includes both mechanical and architectural drawing) and headed the Committee on Dimensioning and Tolerancing. He was Canada's ANSI representative. He represented Canada at two world ISO conferences in Oslo and Paris on the standardization of technical drawings. Cecil Jensen passed away in April, 2005.

## Jay D. Helsel

Jay D. Helsel is professor emeritus of applied engineering and technology at California University of Pennsylvania. He earned the master's degree from Pennsylvania State University and a doctoral degree in educational communications and technology from the University of Pittsburgh. He holds a certificate in airbrush techniques and technical illustration from the Pittsburgh Art Institute. He has worked in industry and has also taught drafting, metalworking, woodworking, and a variety of laboratory and professional courses at both the secondary and the college levels.

Dr. Helsel is now a full-time writer. He coauthored *Engineering Drawing and Design, Fundamentals of Engineering Drawing, Programmed Blueprint Reading,* the popular high school drafting textbook *Mechanical Drawing: Board and CAD Techniques,* now in its thirteenth edition, and *Interpreting Engineering Drawings.*

## Dennis R. Short

Dennis R. Short is professor of computer graphics technology at the School of Technology, Purdue University. He completed his undergraduate and graduate work at Purdue University and also studied at the University of Maryland, College Park. He enjoys teaching traditional engineering design and drafting, computer-aided drafting and design, computer-integrated manufacturing (CIM), and advanced modeling and animation. While at Purdue, he implemented the first instructional CAD system for the School of Technology, as well as the first networked PC-based CAD laboratory. In addition to teaching undergraduates, he is on the graduate faculty. He codirects the Purdue International Center for Entertainment Technology (PICET), a university-level interdisciplinary research and development center. Dr. Short prepared the *Instructor Wraparound Edition for Engineering Drawing and Design,* Fifth and Sixth Editions.

# Contents

PART 1

# BASIC DRAWING AND DESIGN

## OVERVIEW