Preface

Engineering and technical graphics have gone through significant changes in the last decade, due to the use of computers and CAD software. It seems as if some new hardware or software development that impacts technical graphics is occurring every year. Although these changes are important to the subject of technical graphics, there is much about the curriculum that has not changed. Engineers and technologists still find it necessary to communicate and interpret designs, using graphics methods such as drawings or computer models. As powerful as today's computers and CAD software have become, they are of little use to engineers and technologists who do not fully understand fundamental graphics principles and 3-D modeling strategies or do not possess a high-level visualization ability.

To the authors of this text, teaching graphics is not a job; it is a "life mission." We feel that teaching is an important profession, and that the education of our engineers is critical to the future of our country. Further, we believe that technical graphics is an essential, fundamental part of a technologist's education. We also believe that many topics in graphics and the visualization process can be very difficult for some students to understand and learn. For these and other reasons, we have developed this text, which addresses both traditional and modern elements of technical graphics, using what we believe to be an interesting and straightforward approach.

In Chapter 1, you will learn about the "team" concept for solving design problems. The authors of this text used this concept, putting together a team of authors, reviewers, industry representatives, focus groups, and illustrators, and combining that team with the publishing expertise at McGraw-Hill to develop a modern approach to the teaching of technical graphics.

This new-generation graphics text therefore is based on the premise that there must be some fundamental changes in the content and process of graphics instruction. Although many graphics concepts remain the same, the fields of engineering and technical graphics are in a transition phase from hand tools to the computer, and the emphasis of instruction is changing from drafter to 3-D geometric modeler, using computers instead of paper and pencil. We realize that hand sketching will continue to be an important part of engineering and technical graphics for some time to come. Therefore, the text contains an appropriate mix of hand sketching and CAD instruction.

Goals of the Text

The primary goal of this text is to help the engineering and technology student learn the techniques and standard practices of technical graphics, so that design ideas can be adequately communicated and produced. The text concentrates on the concepts and skills necessary for sketching, 2-D, and 3-D CAD modeling. The primary goals of the text are to show how to:

1. Clearly represent and control mental images.
2. Graphically represent technical designs, using accepted standard practices.
3. Use plane and solid geometric forms to create and communicate design solutions.
4. Analyze graphics models, using descriptive and spatial geometry.
5. Solve technical design problems, using CAD and 3-D modeling.
6. Communicate graphically, using sketches, and CAD.
7. Apply technical graphics principles to many engineering disciplines.

What Is Different and Why

A major shift in this edition of the text is toward a strong emphasis on the 3-D model as the focal point for graphics communication with technical drawings as an intelligent by-product of the model. As such, there is a very strong emphasis on *3-D solid modeling* exercises and problems in this edition. Extensive attention has been given to making 3-D solid modeling a primary method for creating technical and engineering graphics for design, documentation, manufacturing, and product management. Looking toward the future role of computer graphics in product design and development, new solid modeling exercises and problems in Chapters 3, 4, 5, 6, 7, 8, 9 and 11 have been designed that focus on the following:

1. The creation of intelligent constraint based 3-D solid models based on their design intent.
2. Placing a strong emphasis on creating 3-D models based on the assembly and operability of mechanisms viewed as products as opposed to individual pieces and parts.
3. Making 3-D models that can become the core of the data pipeline for design, manufacturing, marketing, documentation, maintenance and general communication concerning that product.

The 6th edition of Fundamentals of Graphics Communication contains a more focused look at leveraging the 3-D model as a communications mechanism throughout the product lifecycle. It includes the following items:

- A discussion of neutral file formats for data exchange
- A focus on model-based practice problems
- An overview of product lifecycle management, with the 3-D model playing a central role
- An initial review of current 3-D lightweight file formats used for displaying product model information.

Fundamentals of Graphics Communication presents a modern approach to engineering graphics, providing students with a strong foundation in 3-D solid modeling techniques and graphics communication in the engineering design process. The goal of this text is to help students learn the techniques and practices of technical graphics, enabling them to create and communicate successful design ideas. Design concepts are well integrated, including team design exercises and current design examples from industry.

Features of this Edition Include

- NEW!!! The sixth edition features new 3-D solid modeling documentation and sketches. Solid modeling creation and editing techniques are presented with new learning activities, as well as discussions of standards and CAD data exchange. The 3-D solid modeling activities focus on the assembly, design, and function of products through the inclusion of new assembly modeling projects. New exercises also emphasize visualization, graphical and spatial problem solving through the use of interactive solid modeling, sketching and related documentation.
- Specific references to CAD are integrated throughout the text to illustrate how CAD is used in the context of the topic being explained.
- Precise, full-color illustrations allow students to actually SEE the power of graphics and bring important concepts to life.
- The engineering design process is presented in Chapter 1 and revisited frequently.
- Visualization techniques are discussed in Chapter 5 and throughout the text. Many exercises reinforce the importance of developing good visualization skills.
- Design in Industry boxes are presented to illustrate how graphics and design are being used in industry today.
- Dream High Tech Jobs explain how engineers and technologists have found interesting jobs after completing their education. You will read about how they are using their knowledge and skills to design products, devices, and systems.
- Many examples that use step-by-step procedures with illustrations are used to demonstrate how to create graphics elements or to solve problems. These step-by-step procedures show the student in simple terms how a model or drawing is produced.
- Discussion of file formats used in current model data exchange and archival practices.
- A robust website for this text includes quiz questions, images from the textbook, animations, and many other useful assets. The website is available at www.mhhe.com/bertoline.

Chapter Features

Every chapter has been planned carefully and written with a consistent writing, illustration, and design style and pedagogy. Students and instructors will learn quickly where to find information within chapters. The book was written as a part of a more global instructional approach to engineering and technical graphics and will serve as a starting point for instructor and student.

Here is a sampling of the features inside *Fundamentals:*

Objectives   Each chapter has a list of measurable objectives that can be used as a guide when studying the material presented in the text. Instructors also can use the objectives as a guide when writing tests and quizzes. The tests and quizzes included on the website for the text include questions for each objective in every chapter. This feature allows instructors to make sure that students learn and are tested based on the listed objectives.

Color as a Learning Tool   This textbook uses four-color illustrations throughout to better present the material and improve learning. The selection and use of color in the text are consistent to enhance learning and teaching. Many of the color illustrations also are available to the instructor in the image library found on the website to supplement lectures, as explained in detail later in this Preface.

The use of color in the text was used specifically to enhance teaching, learning, and visualization. Workplanes are represented as a light pink (Figure 4.11). Projection and picture planes are a light purple color (Figure 5.10).

Important information in a figure is shown in red to highlight the feature and draw the attention of the reader (Figure 3.6). Color shading is often used on pictorial illustrations so the user can better visualize the three-dimensional form of the object (Figure 5.43). This is especially important for most students who are being asked to use their visual mode to think and create. Color shading highlights important features, more clearly shows different sides of objects, and adds more realism to the object being viewed.
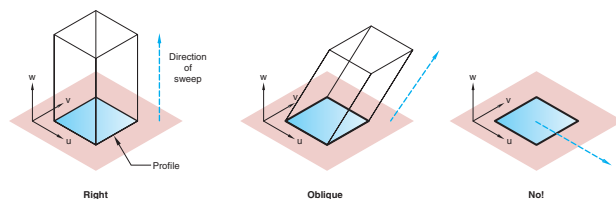
Some texts use two colors, which are adequate for some illustrations, but our research with students clearly demonstrates that having the ability to display objects and text illustrations in many different colors is a huge advantage when teaching engineering and technical graphics.

Photographs and grabs of computer screens are much more interesting and show much more detail when in color (Figure 1.44). Many texts use four-color inserts to supplement the lack of color in the text. This forces students to search the color insert section or look at the insert out of
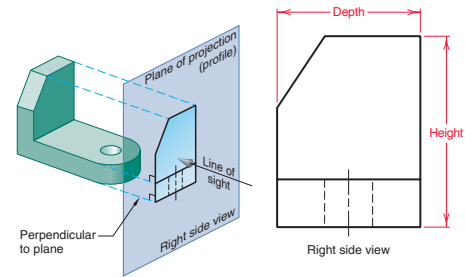

Figure 5.10   **Profile view**

A right side view of the object is created by projecting onto the profile plane of projection.
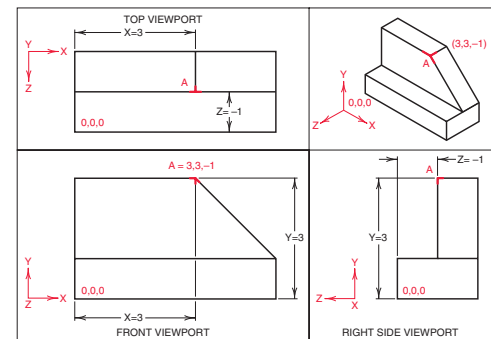

Figure 3.6   **Display of coordinate axes in a multiview CAD drawing**
Only two of the three coordinates can be seen in each view.
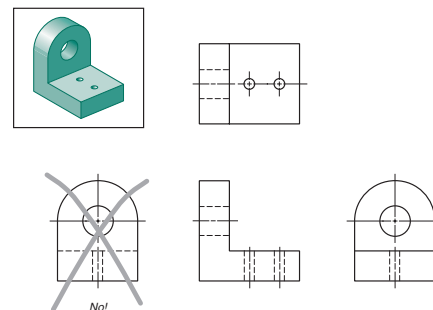

Figure 5.43   Most descriptive views
Select those views that are the most descriptive and have the fewest hidden lines. In this example, the right side view has fewer hidden lines than the left side view.

Figure 4.11   **Types of linear sweeping operations**

In some systems, linear sweeps are restricted to being perpendicular to the sketch plane.

Figure 1.44 **A computer-rendered image created by the technical illustrator using the CAD model**
The technical illustrator can import the 3-D CAD model into a rendering program, where surface textures and light sources are applied.

(Courtesy of Robert McNeel & Associates.)

▼ **Practice Problem 9.1**

Sketch dimensions in decimal inches for the object shown in the multiview drawing.

Practice Exercise 7.2

Using isometric grid paper, sketch common, everyday objects. Some examples are given in Figure 7.22. Sketch objects with a variety of features. Some should require sketching isometric ellipses, while others should have angled surfaces that require nonisometric lines. Start with simpler forms that only contain isometric lines and work toward more complex forms. Another approach is simply to leave out some of the details. You can capture the *essence* of the form by representing just its primary features. This is a common approach in creating ideation sketches.

The cost and availability of isometric grid paper can be a discouraging factor in using it to create lots of sketches. You can minimize the expense by using roll tracing paper over a sheet of grid paper. The two sheets can be held together with low-tack tape or put in a clipboard. With practice, you will find that grid paper is not needed and you can create sketches on the tracing paper alone.

context of the readings. In some aspects of engineering design, such as finite element analysis, color is the method used to communicate or highlight areas of stress or temperature.
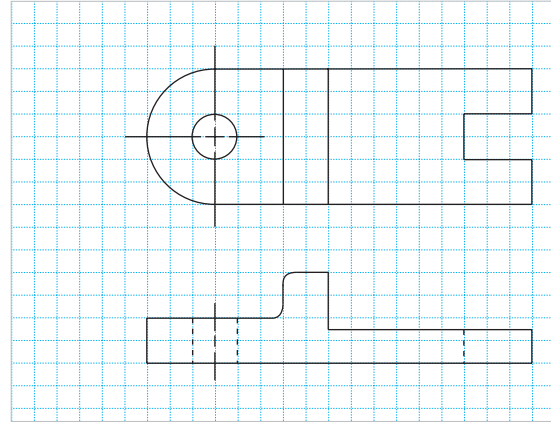
Design in Industry   Every chapter includes a special feature covering some aspect of design as practiced in industry. This Design in Industry feature covers design in many types of industries so that students with varied engineering interests can see how design is used to solve problems. Many feature quotes from engineers working in industry explaining how they solved problems or used CAD tools to enhance the design process. All the Design in Industry items include figures to supplement the information presented.

Practice Problems   This feature gives students drawing practice as they learn new concepts. Through immediate hands-on practice, students more readily can grasp the chapter material. To illustrate, in Chapter 9, "Dimensioning and Tolerancing Practices," Practice Problem 9.1 provides a grid for students to sketch dimensions in a multiview drawing.

Practice Exercises   A unique feature of the text is the use of practice exercises, which cause the student to pause and actively engage in some activity that immediately reinforces their learning. For example, Practice Exercise 7.2 in Chapter 7, "Pictorial Projections," asks the student to find a few familiar objects and begin making isometric sketches. This exercise allows a student to experience and try making isometric sketches without the pressure of graded assignments. Students have the opportunity to try to sketch isometric features, such as ellipses, and practice

before having a formal assignment. They also are working with known objects that they can pick up and move, which is important in the visualization process. Being able to pick up objects is especially important for that segment of the population who are haptic learners and learn best when able to manipulate objects to be visualized.

Step-by-Step Illustrated Procedures   Most chapters include many drawing examples that use step-by-step procedures with illustrations to demonstrate how to create graphics elements or to solve problems (Figure 5.110).

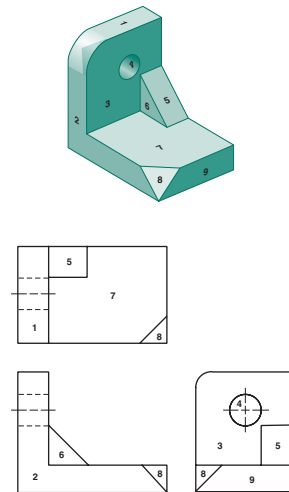**Integration of CAD Modeling**   Every chapter includes specific references to CAD modeling rather than simply

Figure 5.110   **Surface labeling**
To check the accuracy of multiview drawings, surfaces can be labeled and compared to those in the pictorial view.
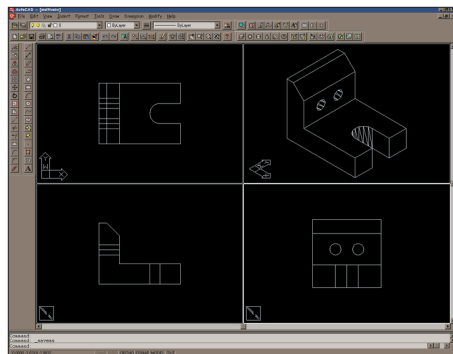

Figure 5.35   Predefined multiviews on a CAD system

adding them to the end of the chapter. CAD modeling is integrated fully and embraced as a means of creating graphics for engineers and technologists (Figure 5.35).

Dream High Tech Jobs   This feature is included in many chapters and explains how engineers and technologists have found interesting jobs after completing their education. You will read about how they are using their knowledge and skills to design precuts, devices, and systems.

Questions for Review   Each chapter includes an extensive list of questions for review. Included are questions meant to measure whether students learned the objective listed at

the start of each chapter. Other questions are used to reinforce the most important information presented in the chapter. The types of questions used require students to answer through writing or through sketching and drawing. Answers to questions are included in the instructor material included with the text.

Further Reading   Many of the chapters include a list of books or articles from periodicals relevant to the content covered in the text.

Problems   Every chapter in the text includes an extensive number and variety of problem assignments. Most chapters include text-based problems that describe a problem to solve or drawing to create. The figure-based problems are very extensive and range from the very simple to complex. This arrangement allows the instructor to carefully increase the complexity of the problems as students learn and progress. The most complex drawings can be used to supplement assignments given to the most talented students or for group-based projects.

Most of the problems are of real parts made of plastic or light metals, materials commonly found in industry today.

The wide range and number of problems allow the instructor to frequently change assignments so that fresh problems are used from semester to semester. Additional problems are available on the website and through our workbooks. Most problems' solutions are provided to the instructor. Instructors may receive access to these password-protected solutions by contacting their local McGraw-Hill sales representative.

Classic Problems   Many chapters include Classic Problems, which are additional problems that can be assigned. They have been taken from the seminal technical graphics textbooks by Thomas E. French, published by McGraw-Hill. Many of the problems are castings with machined surfaces, giving the student experience with additional materials and machining processes.

Glossary, Appendixes, and Index

At the end of the text is an extensive glossary containing the definitions of key terms shown in bold in the text. This glossary contains over 600 terms related to engineering and technical drawing, engineering design, CAD, and manufacturing.

Fundamentals of Graphics Communication, 6th edition contains supplementary information in the Appendixes useful to students, such as metric equivalents,

trigonometry functions, ANSI standard tables, welding symbols, and more.

An extensive index is included at the end of the text to assist the reader in finding topics quickly. This index is carefully cross-referenced so related terms easily can be found by the user.

Website

The website follows the textbook chapter by chapter. As students study, they can refer to the website for learning objectives, chapter summaries, video, a glossary, and more. They require no building or maintenance on your part. In fact, they are ready to go the moment you and your students type in www.mhhe.com/bertoline. Before taking an exam, students will know if they're ready thanks to interactive exercises and self-grading quizzes.

A secured Instructor Center stores your essential course materials to save you prep time before class. The Solutions Manual and presentation materials are now just a couple of clicks away. You will also find additional problem material and exercises.

Website Features

Many supplements for each chapter are found on the book's website, including the following:

- Learning Objectives
- Chapter Outline
- Multiple-Choice Quiz
- Questions for Review
- True or False Questions
- Flashcards
- Website Links
- Animations
- Image Library
- AutoCAD Exercises
- Visualization Exercises
- Stapler 3-D Modeling Project
- Historical Highlights
- Drawing and Sketching Worksheets

Electronic Textbook Option

This text is offered through CourseSmart for both instructors and students. CourseSmart is an online resource where students can purchase the complete text online at almost half the cost of a traditional text. Purchasing the eTextbook allows students to take advantage of Course-Smart's web tools for learning, which include full text search, notes and highlighting, and email tools for sharing notes between classmates. To learn more about CourseSmart options, contact your sales representative or visit www.CourseSmart.com.

University; Jim Hardell, Virginia Polytechnic Institute; and Murari Shah, Purdue University. Thanks to Kevin Bertoline for the solutions to some of the "Classic Problems" and sketches in the third edition. Jason Bube and Travis Fuerst contributed updated and new illustrations in the third edition. Special thanks must go to Michael Pleck from the University of Illinois. Professor Pleck has spent countless hours reviewing the text and giving the authors many ideas on how to improve the content. Professor Pleck has shared his vast knowledge in graphics because of his dedication to the profession. The authors truly are indebted to him and greatly appreciate all he has done.

The authors also would like to thank the publisher, McGraw-Hill, for its support of this project. This has been an expensive and time-consuming process for the authors and the publisher. Few publishers are willing to make the investment necessary to produce a comprehensive, modern graphics text from scratch. The technical graphics profession is indebted to McGraw-Hill for taking the risk of defining a discipline in transition.

Gary Bertoline would like to especially thank his wife, Ada, and his children, Bryan, Kevin, and Carolyn. His thanks also go to Caroline and Robert Bertoline, who encouraged him to pursue his studies. He also would like to thank all of his colleagues, especially those at Purdue University and The Ohio State University, his instructors at Northern Michigan University who inspired him to pursue graphics as a discipline, and Wallace Rigotti, who taught him the basics.

Eric Wiebe would like to thank his wife, Cynthia Shimer, for the support she has given and to recognize the sacrifices his children, Ellery and Colin, have made over the years of authoring this and other editions of the text. He would also like to thank his father, Robert Wiebe, who provided the best role model of a scholar, author, and father one could hope for. His thanks also extend to his fellow faculty in the Graphic Communications program at North Carolina State University for the collegiality they have provided over the years. Finally, thanks go to Ted Branoff for the discussions, advice, and specific input he has given over the last few years that have helped to shape his writing.

William Ross would specifically like to thank his wife Linda for the support, patience, sacrifice, love, and encouragement she has given during the creation of this text. For helping to develop the insight and imagination needed to create new and original problems in 3-D solid modeling, he would like to thank his parents and those special mentors and teachers who inspired him to be a wide-open visual and spatial thinker along the way. Special thanks go to Pat Connolly of Purdue University for his enthusiasm and support in helping to field test many of the new solid modeling problems in his classes at Purdue. He would also like to thank all of his colleagues, especially those at North Carolina State University and Purdue University whose loyal encouragement and friendship have made engineering graphics a wonderful career choice.

Nathan Hartman would like to thank his wife, Heather, and his children, Thomas, Meghan, and Cooper for allowing him to spend time away from them to complete his work on this edition of the text. His thanks also go to his parents for being his best teachers in life. To his colleagues at Purdue University and North Carolina State University, he owes much gratitude for the opportunities they gave him during formative times in his career. Finally, Nathan would like to extend thanks to this author team, whom he has known as teachers, colleagues and friends.

Finally, we would like to know if this book fulfills your needs. We have assembled a "team" of authors and curriculum specialists to develop graphics instructional material. As a user of this textbook, you are a part of this "team," and we value your comments and suggestions. Please let us know if there are any misstatements, which we can then correct, or if you have any ideas for improving the material presented. Write in care of the publisher, McGraw-Hill, or E-mail Gary R. Bertoline at bertoline@purdue.edu.

Gary R. Bertoline
Eric N. Wiebe
Nathan W. Hartman
William A. Ross